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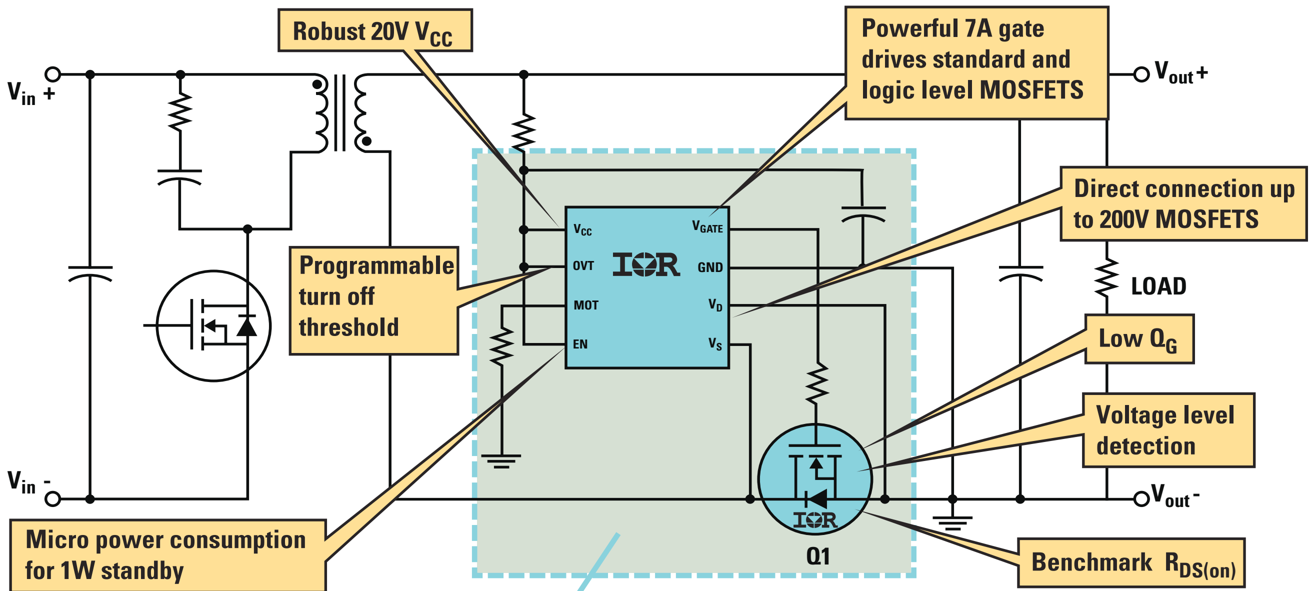
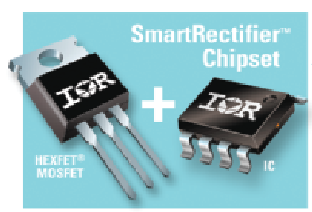
DITCH YOUR HEATSINK

New SmartRectifier™ Chipset Reduces Part Count by 75% and Boosts System Efficiency by 1%





IR's new SmartRectifier™ chipset for AC-DC power converters dramatically simplifies design and improves efficiency in secondary synchronous rectification (SR) flyback and resonant half-bridge circuits, enabling a "no heatsink required" design.

Specifications

ICs

Part Number	Package	V_{CC} (V)	V_{FET} (V)	Sw. Freq. Max. (kHz)	Gate Drive	V_{GATE} Clamp (V)	Sleep Current Max. (µA)
IR1167A/SPbF	DIP-8/SO-8	20	<=200	500	+2A/-7A	10.7	200
IR1167B/SPbF	DIP-8/SO-8	20	<=200	500	+2A/-7A	14.5	200
IR1166/SPbF	DIP-8/SO-8	20	<=200	500	+1A/-3.5A	10.7	200

MOSFETS

Part Number	V_{DSS} (V)	$R_{DS(on)}$ max @ 10V (mΩ)	$Q_{G(typ/max)}$ (nC)	Package
IRFB3206PbF	60	3.0	120/170	TO-220
IRFB3207PbF	75	4.1	120/170	TO-220
IRF7853PbF	100	18	28/39	SO-8

Features

- Can increase system efficiency by more than 1%
- Reduces part count by up to 75%
- Works independently from primary-side control
- No current transformer required
- Industry-leading high voltage IC technology

Design Tools

A data sheet, application notes, technical papers and online design software are now available on IR's myPower™ site (http://www.irf.com/design-center/mypower/).

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Stanford University
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Sandia National Laboratories
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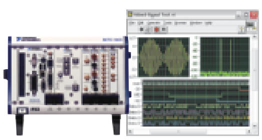
- Software-defined configuration and automation with National Instruments LabVIEW and LabWindows/CVI, C/C++, NI TestStand, and Microsoft .NET



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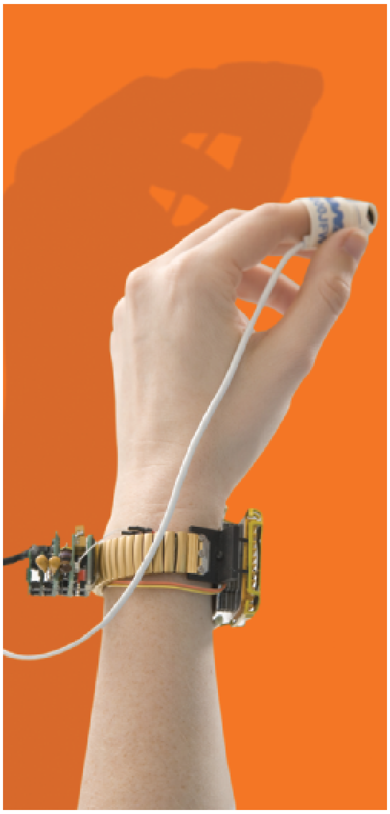
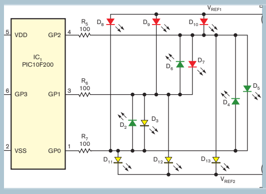


DESIGNIDEAS



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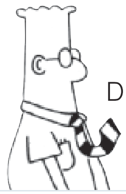

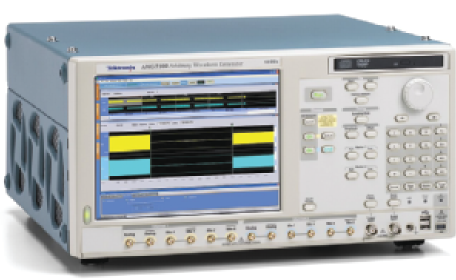

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DEPARTMENTS & COLUMNS

PRODUCT ROUNDUP

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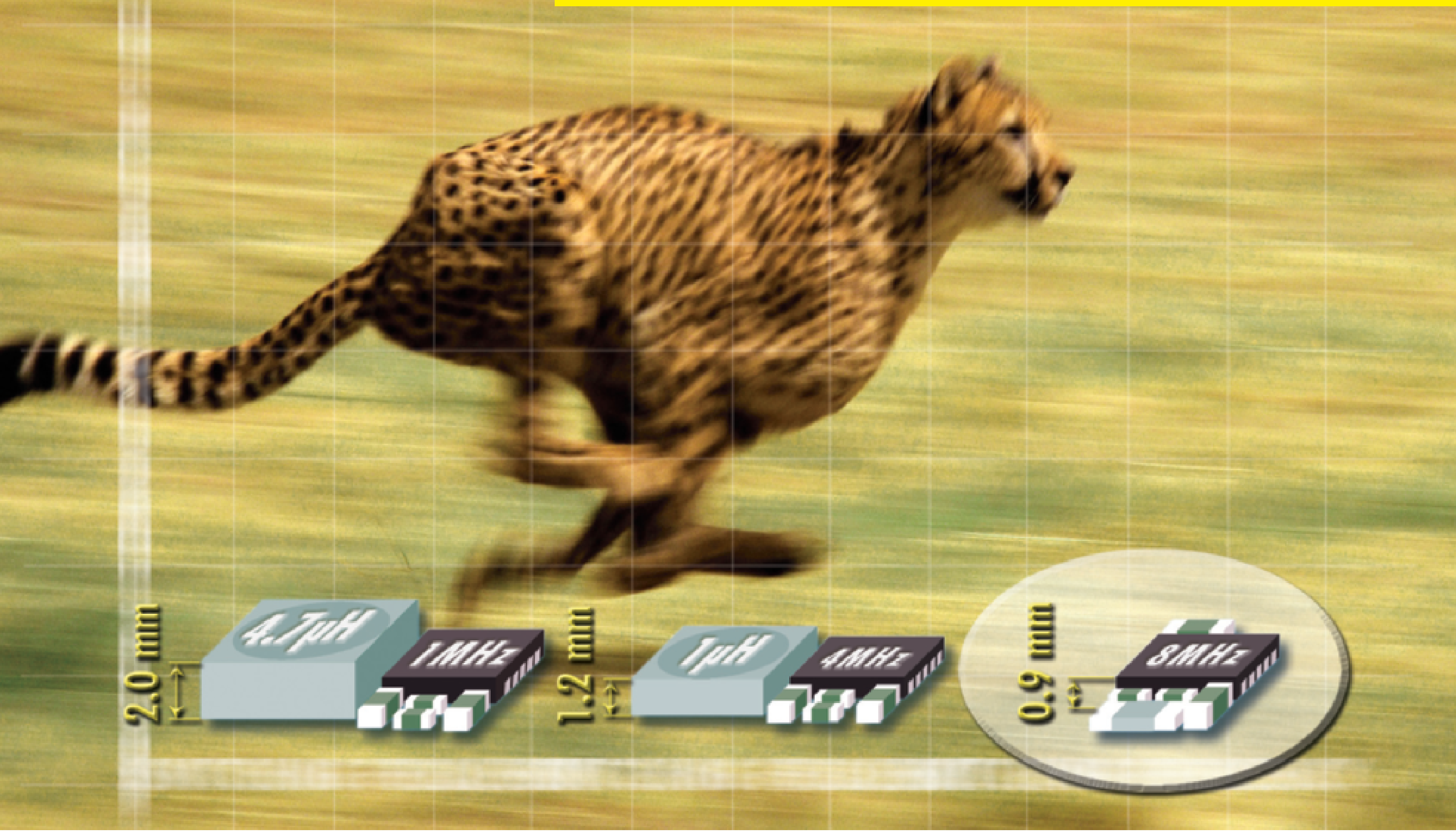
Industry's First 8MHz 500mA Synchronous Buck Regulator

Inductor Size Gets Leaner By Greater Than 95%



Micrel's MIC2285 is a high efficiency 8MHz pulse width modulated (PWM) synchronous buck (stepdown) regulator. It features a LOWQ™ LDO standby mode that draws only 20µA of quiescent current. The MIC2285 is the industry's breakthrough ultra-low noise, small size, and high efficiency solution for portable power applications.

In PWM mode, the MIC2285 operates with a constant frequency 8MHz PWM control. Under light load conditions, such as those in system sleep or standby modes, the PWM switching operation can be disabled to reduce switching losses. In this light load LOWQ mode, the LDO maintains the output voltage and draws only 20µA of quiescent current. The LDO mode of operation saves battery life and does not introduce spurious noise and high ripple which is common place in pulse skipping or bursting mode regulators. The MIC2285 operates from a 2.7V to 5.5V input voltage and features internal power MOSFETs that can supply up to 500mA output current in PWM mode. It can operate with a maximum duty cycle of 100% for use in low-dropout conditions.

For more information, contact your local Micrel sales representative or visit us at: www.micrel.com/ad/mic2285.
Literature: 1 (408) 435-2452 Information: 1 (408) 944-0800

The Good Stuff:

- 2.7 to 5.5V supply/input voltage
- Light load LOWQ LDO mode
- 20µA quiescent current
- > 90% efficiency
- Low noise, 75µVrms
- 100% maximum duty cycle
- Adjustable output voltage option down to 1V
- Ultra-fast transient response
- Ultra-small 0.47µH inductor
- Fully integrated MOSFET switches
- Micropower shutdown operation
- Thermal shutdown and current limit protection
- Pb-free 10-pin 3mm x 3mm MLF™ package
- –40°C to +125°C junction temperature range

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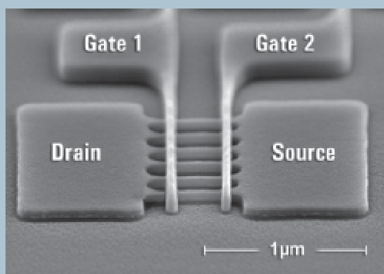

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HOLIDAY DESIGN IDEA

Simple tester checks Christmas-tree lights
→ www.edn.com/article/CA46423
Every year at about this time, a 1999 article with the above headline percolates into the upper layers of our Web-site traffic reports. As folks bring their holiday lights out of storage, burned-out bulbs confound their attempts to deck the halls, which sends them scurrying to Google. There they find a reference to this Design Idea article, written by William Dias, which begins, "Why is it that you always test 48 bulbs before you find the bad one in a 50-light string?"

We're not sure how many people actually build the tester that Dias describes to "divide and conquer, greatly reducing the time it takes to find the bad bulb," but we like to think we're doing our part to spread holiday cheer.

By the way, manufacturers have mostly eliminated the problem in modern light strings. For *that* story see www.edn.com/article/CA46448.

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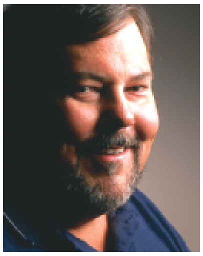

BY MAURY WRIGHT, EDITOR IN CHIEF

A day isn't always a day, but a byte is a byte

I recently returned from a trip to Europe for the biannual Electronica trade show in Munich, Germany. I'm happy to report that high-speed Internet access is now broadly available across Western Europe. But beware if you like to use your notebook to stream data. I found out the hard way that buying access time at some hotels is not nearly as straightforward as it is in North America.

My family and I spent the Sunday before Electronica in the medieval town of Rothenburg ob der Tauber, Germany. We stayed in an old hotel, the Eisenhut, within the walls of the old city. The furnishings may have been antique, but the hotel had Wi-Fi. After dinner, it was bitterly cold and windy in the deserted streets. Everyone voted against the lauded night watchman's tour. I was ready for some football.

The Internet access was a bit pricey by North American standards, as it was throughout most of the trip. Two hours cost about $13, and a 24-hour day was double that price. I knew the San Diego Charger game was probably at halftime, so I bought only two hours of access and connected to my Slingbox here in California.

It was just as well that I had missed the first half because the Chargers had performed miserably, but they really came to play late in the second quarter and in the second half. As the team took control of the game around the end of the third quarter, however, the video stream stopped. And when I finally closed all the windows, revealing the original log-on/off window, I found out why: I had exceeded the number of downloaded bytes that

ISPs that want to do business by the byte should simply do so and forget time.

ISP (Internet-service provider) Swisscom (www.swisscom.com) allows. The fine print reveals that, for two hours of Internet service, you get 150 Mbytes of data. Full-day buyers get 400 Mbytes.

Now, I know that information was buried somewhere in the service agreement that I quickly clicked "yes" to in signing on. But I think ISPs that want to do business by the byte should simply do so and forget time. It turns out that my son also exceeded the limit while watching TV at a Hilton hotel on the trip. Meanwhile, we heavily used the Internet in other hotels in Germany, Ireland, and England without hitting such limits. I've regularly used the Slingbox in North American hotels and have never hit such a limit.

The real downside to such policies is the potential for generally negative experiences of what should be positive technologies. The Slingbox is simply amazing. I bought mine the week that Sling Media (www.slingmedia.com) started shipping it in July 2005. It was a true first-generation product. It worked the day I bought it. And software upgrades have continually improved the video quality and function. I like having the ability to watch my local news while traveling. And it comes in handy for sporting events, as well.

ISPs should do everything in their power to make experiences such as Slingbox positive. Swisscom stands behind a meek claim that it limits bytes to prevent theft of copyrighted material. Of course, that policy would also limit someone from downloading legally purchased content. The ISP would be better served by providing a quality experience so that the service buyer is likely to buy again. I certainly learned to read the fine print. And, with 3G cellular data cards and service proliferating, the hotel ISPs have competition. They may find those profitable Internet-service fees disappearing as quickly as they lost voice-call revenue to travelers carrying mobile handsets. EDN

Contact me at mgwright@edn.com.

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5.8-GHz-bandwidth, 10-bit AWG claims honors as world's fastest

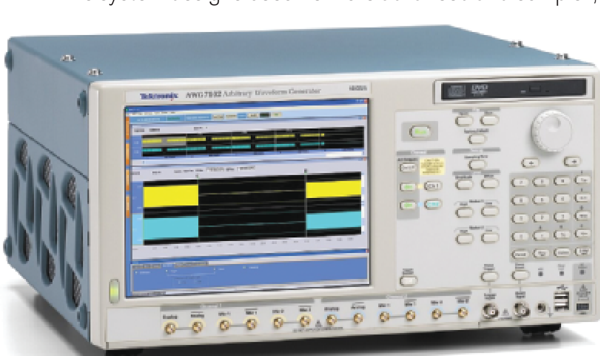
Tektronix has announced the AWG7000 Series of AWGs (arbitrary-waveform generators), which the company calls the fastest such signal sources. Design engineers will use the instruments, which can simultaneously produce as many as six waveforms (two analog, four markers), to test high-speed serial-data buses and wideband digital-RF devices. Through the use of a new SiGe (silicon-germanium) DAC, the units provide 5.8-GHz bandwidth, 10-bit resolution, and sample rates to 20G samples/sec. The generators' ability to produce high-speed and multilevel-signaling waveforms to 10 Gbps with pre- and de-emphasis and imperfections, such as noise and jitter, make them—according to the manufacturer—the fastest, most capable, and most versatile sources of high-speed-serial and wideband-RF signals.

The sample rate has increased from 4.2G samples/sec in previous-generation products to 20G samples/sec, providing, says Tek, four times the performance of any other AWG. Rise time, which is 20 to 80% of the step amplitude, is 45 psec. The units also produce modulated digital-RF/IF signals to 5 GHz for wideband applications, including advanced radar.

"As system designs become more advanced and complex, the ability to create accurate signals in a realistic test environment becomes increasingly important," says David Erisman, chief technology officer of tactical-communication-system-provider X-Com Systems (www.systemsx.com). "The AWG7000's user-interface and waveform-development tools enable engineers to easily generate, very early in the development process, the exact waveform, data stream, or mixed signal for testing design concepts before committing them to hardware." The generators come with a 10.4-in., touch-sensitive color LCD and an intuitive user interface based on Windows XP.

Connectivity features include IEEE 488 and Gigabit Ethernet. The units come with one or two analog channels and two or four marker outputs, enabling the generation of mixed-signal waveforms that include analog- and digital-control components. The units allow data interchange with third-party software, including The MathWorks' (www.mathworks.com) Matlab, Mathsoft's (www.mathsoft.com) MathCad, and Microsoft (www.microsoft.com) Excel, which designers often use to create waveforms. Suggested US retail prices start at $60,000 for a 5G-sample/sec unit with one analog channel.**—by Dan Strassberg**

▷**Tektronix Inc**, www.tektronix.com.



Though it looks like a digital oscilloscope, the AWG7102 is a two-channel arbitrary-waveform generator with what the vendor calls the world's widest bandwidth (5.8 GHz), highest sampling rate (20G samples/sec, optional; 10G standard), and 10-bit vertical resolution.

FROM THE VAULT

"Even the most veteran designers sometimes feel that nature is conspiring against them. In some measure, this is true. Like all engineering endeavors, high-speed circuits can work only if you negotiate compromises with nature. Ignorance of or contempt for physical law is a direct route to frustration. Mother Nature laughs at dilettantes and dabblers. She crushes arrogance unknowingly."

—Jim Williams, Linear Technology, *EDN*, Oct. 10, 1991

Digital-video processor breaks $10 barrier

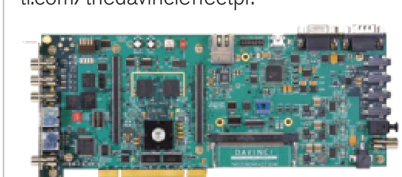
Texas Instruments' DaVinci line of digital-video processors pushes down the cost for digital-media processors to as low as $9.95 with the introduction of four new TMS320DM643x devices. The application-specific processors target the requirements for automotive-vision, video-security, and video-telephony applications. The TMS320DM643x devices consist of a C64x+ DSP core with as much as 32 and 80 kbytes of program and data cache, respectively, and as much as 128 kbytes of on-chip L2 cache. Video-specific peripherals and acceleration blocks include a video-in port; as many as four DACs; and a video-processing subsystem with a CCD controller, a preview engine, a histogram module, video decoders, a resizer, and on-screen-display support. External interfaces include a CANbus (controller-area-network-bus) interface and a choice of Ethernet, PCI, HPI (host-port-interface), and TI's VLynq interfaces.

The DaVinci development-and-software infrastructure aims to bridge the differences between architectures and configurations through APIs so that developers can focus on the application code. How the development environment will abstract the architecture differences is unclear, because TI won't release the development tools until the second quarter of 2007. Texas Instruments will offer µClinux (microcontroller Linux) from VirtualLogix (www.virtuallogix.com) for these devices instead of the MontaVista (www.mvista.com) Linux that supports the dual-heterogenous core DM644x devices. Software development that directly targets the C64x+ DSP core is available through TI's Code Composer.

The devices are available for sampling now, and production will ramp up in the second quarter of 2007. The devices are pin-compatible and AEC-Q100 qualified. The smallest device, the DM6431, is available for $9.95 (10,000), and it can operate at rates as high as 300 MHz. The DM6433, DM6435, and DM6437 operate as fast as 600 MHz and are available with wider peripheral options for $16.35 to $22.95 (10,000).

—by Robert Cravotta

▷**Texas Instruments**, www.ti.com/thedavincieffectpr.



The DaVinci evaluation module includes a development board, Linux-development tools, and MontaVista Professional Edition 4.0 demo software.

PXI line claims to support broad array of instrument-interconnect standards

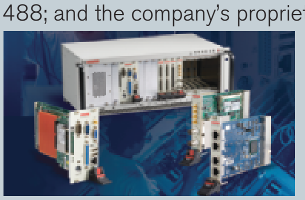
Keithley Instruments has entered the large and rapidly growing PXI-modular-instrumentation market with a bang. The company's announcement of the KPXI line includes simultaneous-data-acquisition boards, multifunction and high-speed analog-I/O boards, a 130M-sample/sec digitizer module, digital-I/O modules, several PXI chassis and embedded-PC controllers, MXI bridges for remote PC control, and IEEE 488-interface cards.

The line includes approximately 16 new hardware products as well as new software. A point-and-click test-code creator automatically generates C-language test code without programming. A configuration/setup tool tests and calibrates the hardware, verifies its operation, and performs diagnostic routines. A set of National Instruments' (www.ni.com) LabView virtual instruments speeds test-code development. Drivers are included for LabView and for Microsoft (www.microsoft.com) .net, Visual Basic, Visual C, C++, and C#. A .DLL interface enables compatibility with virtually all programming environments.

Meanwhile, the manufacturer's support for other standards is also growing to encompass the new Ethernet-based LXI (LAN Extensions for Instrumentation); the venerable IEEE 488; and the company's proprietary TSP (test-script processor), which enables distributed programming and concurrent execution. The reasons for this proliferation are that different standards excel at different jobs and that test engineers have strong opinions about which standard is best for which job. Keithley says that its support for PXI, LXI, IEEE 488, and TSP represents the broadest instrument-interface-standards support of any major instrumentation manufacturer. Within the KPXI line, US list prices start at $325 for modules, $2795 for embedded controllers, and $999 for chassis.

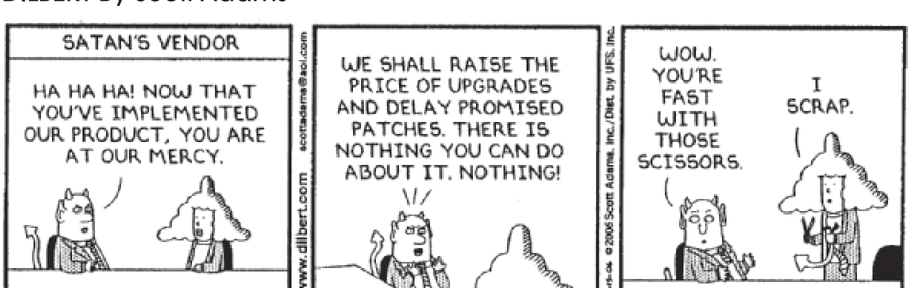
—by Dan Strassberg

▷**Keithley Instruments Inc**, www.keithley.com/pr/064.



The KPXI line of instrument modules, controllers, chassis, and software hits the ground running with approximately 16 hardware products and plenty of software.

DILBERT By Scott Adams



65-nm FPGAs consume less power

Altera Corp has announced the high-end Stratix III FPGA, the company's first in 65-nm process technology, claiming advances in power, performance, productivity, and price over its 90-nm FPGAs. According to Dave Greenfield, senior director of product marketing for high-end FPGAs at Altera, the company is increasing the number of logic elements from 180,000 to 340,000, the amount of memory from 8 to 17 Mbits, and the number of 18×18-bit DSP multipliers on board. Altera, like its archrival Xilinx (www.xilinx.com) with Virtex-5, has made power saving a top priority in developing its new 65-nm FPGA family, the Stratix III (see "FPGAs balance lower power, smaller nodes drip by drip," *EDN*, June 8, 2006, pg 58, www.edn.com/article/CA6339245).

Large, SRAM-based FPGAs have traditionally been power hogs, because all the transistors on a device consume power, even if the design layout doesn't use those transistors. Also, 65-nm processes inherently have more leakage than 90-nm processes because the increase in ever-thinner oxide transistors results in more static-power losses. To save power with its 90-nm Stratix II devices, Altera a few years ago made an eight-ALM (adaptive-logic-module) device the centerpiece of its Stratix II devices. Each FPGA contained tens of thousands of ALMs. An ALM could locally perform computation rather than accessing data in disparate and distant parts of the FPGA. Thus, ALM-based architectures consume less power than traditional architectures.

With the new Stratix III, says Greenfield, Altera stayed with the eight-ALM structure but kept power on par with its 90-nm devices by employing other architectural improvements. One way that the company saved power is by creating configurable-logic elements that designers can choose to be either high-performance and low-power-consuming or low-performance and consuming half the power of Stratix II devices, depending on their targeted application.

Altera performed a study on 71 customer designs. The study indicates that, even in designs that customers consider high-performance applications, only about 15% of the logic on those designs on average require high-performance logic elements. The remaining 85% of the logic thus require no high-performance logic elements. Therefore, if designers can power down a large percentage of the logic of their designs, they can significantly cut overall power consumption.

In addition, the devices also achieve power savings through the process reduction, because the 65-nm devices, which Altera implemented in TSMC's (Taiwan Semiconductor Manufacturing Co, www.tsmc.com) 65-nm process, come in either 0.9 or 1.1V core-power settings. Greenfield notes that 0.9V will be sufficient for designs that don't require a lot of high-performance logic, whereas the 1.1V version will suit devices for high-performance applications.

The Stratix III manufacturing at TSMC incorporates all-copper routing; low-K dielectrics; strained silicon; and triple oxide, which helps stabilize power savings during the process reduction. The new devices operate an average of 25% faster than Stratix II devices and have a top clock speed of 600 MHz. Stratix III can also now support high-speed DDR3 and QDR+ interfaces at clock rates of 400 MHz, which Stratix II does not support. Stratix III also supports interfaces for DDR, DDR2, SDRAM, RLDRAM (reduced-latency DRAM) II, QDR II, and SRAM on as many as 24 modular I/O banks—all at higher clock rates than those of Stratix II.

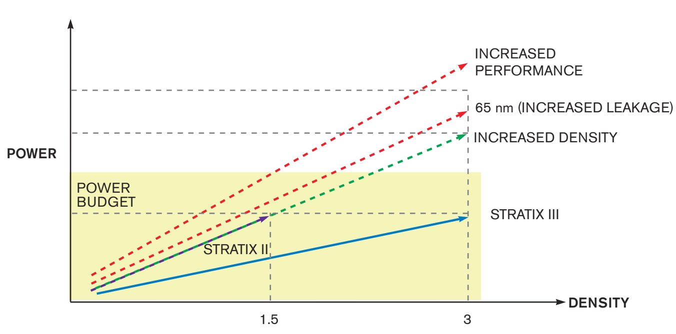
Stratix III also has double the capacity of the Stratix II devices. The highest end Stratix III FPGA has 330,000 logic elements, which means designers can now use Altera FPGAs to serve as the heart of a system, instead of using them for glue and control logic. Because the devices are now so large, it is more than likely that it will now take a full design group to program one of the large devices.

Therefore, the company has put greater emphasis on adding team-based-design features and automation to its latest upgrade of Quartus II software, Version 6.1, to make designers more productive. The latest version includes multiprocessor support, detachable Windows support, a chip planner, advanced I/O timing, and pin-planning enhancements. Altera now offers a Windows 64-bit version of Quartus II 6.1 as well as expanded Linux support for SUSE (Gesellschaft für Software und Systementwicklung MBH, www.opensuse.org) Linux Enterprise 9 as well as Red Hat Enterprise (www.redhat.com). Prices for the 142,000-logic-element EP3SL150, will start at $550 (1000). The company expects volume production to begin in 2008.

As with Stratix II, the company plans to offer Stratix III in three families: the Stratix III L logic-enhanced family; the Stratix III E family with enhanced memory and DSP functions for memory- and DSP-intensive applications; and the Stratix III GX family for transceiver applications. Altera will also offer a Hard Copy-structured ASIC variant.

—by Michael Santarini

▷**Altera**, www.altera.com.



Altera claims that Stratix III FPGAs consume half the power of the equivalent number of gates in its 90-nm Stratix II.

VOICES

Richard Tobias: The SOC's the thing

Richard Tobias is chief technology officer at Pixelworks (www.pixelworks.com), a maker of SOCs (systems on chips) for the video and display markets. In his current role at Pixelworks and in his previous role as vice president of Toshiba's (www.toshiba.com) ASIC and Foundry Business Unit, Tobias has been an active participant in many IC-design-methodology and EDA-industry-related panels on topics ranging from ESL (electronic-system level) to DFM (design for manufacturing) to EDA interoperability. Currently, Tobias manages hundreds of engineers worldwide at Pixelworks and is an advocate of platform-based SOC design (see "ASIC-design managers face global challenges," *EDN*, Oct 12, 2006, pg 61, www.edn.com/article/CA6378082). Last month, *EDN* asked him a few questions about the current state of IC design and got his views on the hot EDA technologies.

You've been a regular on EDA panels for years representing the "users'" point of view. Why have you been so involved in EDA-related panels? Are you a glutton for punishment, or do you hope to influence change?

A It's probably more of the first than the second, but I've always thought that automation is the key. Without strong EDA companies, there really wouldn't be any electronics companies.

So, I've been active in helping steer EDA companies in the directions they need to go to help us. I've helped EDA start-ups get funding. And, when I was at Toshiba, I even helped them get funding from Toshiba. I'm a big advocate of the big four in EDA [Cadence, www.cadence.com; Synopsys, www.synopsys.com; Mentor, www.mentor.com; and Magma, www.magma-da.com], as well as the little guys.

What are the largest pain points in the SOC-design process today?

A For us fabless guys, there are still issues in DFM, but it certainly isn't as bad as it was a year ago. Most of us were worried that the foundries were not going to release the process data that we need for DFM tools to work properly, but they've come around a bit. They are now offering the data encrypted. I think it will play out much like Spice did. In the mid-1980s, folks were really worried about keeping Spice models proprietary. Then, after a while, they started to release the models encrypted. Now, you can pretty much get them freely. I think DFM will go the same way. In another five years, I bet we won't have encrypted files. That stuff will all go away, and the foundries will compete on some other thing. They think it is something intrinsic about their process, but that's all hogwash.

Today, the big fabless customers get all the information they want, and so do the midsized players. Today, it's probably hardest for the start-ups in the fabless space, but withholding the data only hurts the fabs. If you don't sell any wafers, then you don't make any money. And, if you don't let these small guys get to beta, you don't sell them wafers, and they can't grow into big customers; it's a self-fulfilling prophecy of failure. The foundries will get it eventually. It'll get easier.

We also still need ESL tools that will help us with system-oriented design. There are a lot of knits that you have to put together. You take a bus-structure, models, IP [intellectual property], and some tools, and you put them together to create a system. But the solution I put together at Toshiba is different from the system I put together for Pixelworks. If I moved to another company, I'm sure I'd probably have different requirements. So, the question is how do you build an EDA company that can accommodate all those requirements and different application spaces? There certainly is a need for ESL. I think there are a lot of niche tools that can be built around the Open Core Protocol, and there are some tiny start-ups in that space. I'm hoping that one of the big vendors—Cadence, Synopsys, or Mentor—could snatch them all up and put together a comprehensive ESL offering. A lot of us are combining those tools with FPGA-based prototyping systems; there aren't any full commercial offerings, so there are a lot of homegrown systems.

Another area where the EDA industry could help out is in design collaboration. Some companies are doing it, but they aren't doing a good enough job. We've had to build our own collaboration database. We have huge files: 10-Gbyte GDSII files or even bigger—up to a terabyte. How do you replicate that [file] across seven to 10 design sites? Something that's seemingly that simple isn't out there commercially. We've been looking for commercial solutions, but, in the end, we've had to piece something together on our own.

What EDA start-ups are catching your interest these days?

A Off the top of my head, we really like this analog-tool start-up out of Leuven, Belgium, called Kimotion [www.kimotion.com]. It has a promising technology to help you get to a solution faster; the company does yield analysis, too. We're also using [ChipIt's, www.uchipit.com] ProDesign for building an FPGA-based prototyping box. The company builds FPGA-prototyping systems that are regularized.

Also in the tool space, were evaluating companies doing simulation acceleration. We're also using the parallel bus from Arteris [www.arteris.com].

—by Michael Santarini

RAQ's

Rarely Asked Questions

Strange but true stories from the call logs of Analog Devices

Contributing Writer James Bryant has been a European Applications Manager with Analog Devices since 1982. He holds a degree in Physics and Philosophy from the University of Leeds. He is also C.Eng., Eur.Eng., MIEE, and an FBIS. In addition to his passion for engineering, James is a radio ham and holds the call sign G4CLF.

More Chips are Better than One (or the Benefits of Belgian Food)

Q. *When are two chips better than one?*

A. When two chips ~~are tastier~~ work better, cost less, and get you to market faster.

The Belgians who invented chips and still make the best in the World serve them with mayonnaise. I can't imagine why Americans call them "French fries". In Belgium recently discussing (silicon) chips with a Belgian colleague, I had to point out that with integrated circuit chips, as with potato chips, quality is more important than size. More potato chips are good—and this is sometimes true of silicon ones too.

Integration is one of the most powerful forces in our industry—we have Moore's Law to mandate it. Increased integration has provided smaller size, lower cost, and greater power efficiency. This is good but total integration—a whole system on one chip—is not always best.

Nanometer CMOS integrates huge amounts of digital circuitry, but also forces lower supply voltages and a worse signal to noise ratio. If a system needs precision analog circuitry or robust digital interfaces it cannot cope.

We can make chips combining nanometer CMOS with higher voltage devices, bipolar or CMOS, to handle analog and higher voltage digital functions. But such multi-process chips yield less and cost more. Carefully partitioning a system into two or more chips often gives less reject silicon for less cost than one massive chip with relatively poor yield.

Such partitioning takes great skill. The designer must optimize size, cost, power, functionality and time to market. His/her tools are circuit and system design skills and advanced IC processes.

Designing the latest and greatest system on a chip is great, but if you're late to market you might as well skip work and go fishing or shopping. Often the quickest solution uses separate computational and analog high level digital chips. One way of achieving such a solution quickly is to use an FPGA as the computational chip. While this is rarely the lowest cost or highest density solution, it can prevent a missed opportunity while a cheaper purpose-built, but longer in development, chip takes over later in the product lifecycle.

The analog chip need not be all that simple. Modern analog chips frequently contain powerful digital processing—examples include sigma-delta (S-D) converters and smart interpolating DACs which contain (for example) firmware to separate interleaved QAM input data and digital interpolation to reduce demands on the output anti-aliasing filter.

I'm not proposing to repeal Moore's Law—integration is still good. But often smart partitioning rather than total integration improves your product while letting you get to market ahead of your competition. Then you can celebrate—the Belgians make some of the best beers in the World, too.

To learn more about smart partitioning,
Go to: http://rbi.ims.ca/4943-101

Have a question involving a perplexing or unusual analog problem? Submit your question to:

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For Analog Devices' Technical Support, call 800-ANALOGD

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Sigma-delta ADC IP block offers programmable resolution

IP (intellectual-property) provider Chipidea is expanding its ADC offerings to include a range of sigma-delta cores that provide programmabilty during operation for either high resolution or low power consumption. You can use the cores in SOC (system-on-chip)-product designs that will process multiple standards, in bandwidths of 100 kHz to 10 MHz, typically digitizing the output from a radio block in a portable device. Resolution is as high as 16 bits, and users can configure the core as a matched I/Q converter or as part of a complete analog front end.

The IP includes programmable decimating filters. Because the ADC is programmable, you can use a single converter to digitize the output from more than one RF front end. According to Chief Technology Officer Carlos Leme, applications such as DVB-H (digital-video broadcast-handheld) require a conversion bandwidth of approximately 4 MHz, which is well within the core's capabilities; the same is true for standards from cellular phones to Wi-Fi and WiMax. You implement the IP in standard digital CMOS; the sigma-delta architecture yields good immunity to interference from power supplies and substrate noise. You can use the IP to build a single stand-alone ADC, a matched IQ-ADC, or part of an analog front end. It comes with a PLL for clock generation, plus analog and digital filters. It is now available in 0.18-micron and 130-nm technologies; 90- and 65-nm technologies are in development.

You can easily port the IP to different foundries, partly because of its switched-capacitor-based architecture. A specified operating point is 4.5-mA current demand for 64 dB in 3 MHz from a circuit block measuring less than 0.42 mm^2. The design achieves programmability without area or power penalty, Leme says.

Variants include the 11- to 13-bit, 120-MHz programmable CI3621tl and CI3621ul ADC with 200-kHz and 4-MHz bandwidth and the 11-bit, 120-MHz CI3617tn ADC with 4-MHz bandwidth.

—by Graham Prophet, *EDN Europe*

▷**Chipidea**, www.chipidea.com.

Mobile-phone use to rise in Africa, India

According to iSuppli Corp, mobile phones are becoming increasingly ubiquitous, even among low-income subscribers in the Third World. For mobile-phone makers, this phenomenon is posing both challenges and opportunities as they strive to offer lower cost products that appeal to developing nations. Speaking at the iSuppli 2006 North American conference, iSuppli analysts discussed the emerging market for such inexpensive phones, including a new breed of ultralow-cost handsets. "The level of penetration globally for wireless communications is astounding," said Dale Ford, vice president of market intelligence for iSuppli. "Nothing, except for electrical power, comes close."

The number of worldwide subscribers for wireless-communications services is expected to increase to 4 billion by 2010, up from 2.6 billion in 2006, according to iSuppli. New subscribers in developing nations are largely responsible for this growth. Key regions, including Africa, the Middle East, and India, are driving this growth. Despite this increase in the number of subscribers in these countries, global wireless-communications-subscriber growth is decelerating as markets in developed nations become increasingly saturated. This fact makes the developing regions vitally important to the continued growth of the mobile-phone business.

India is one of the key regions driving subscription growth, according to Jagdish Rebello, PhD, director and principal analyst for iSuppli, who also spoke at the 2006 North American Briefing. "India had more than 6 million new mobile-phone subscriber additions in September, making it the fastest-growing wireless market in the world," Rebello said. He cited an iSuppli forecast showing that India will have 405 million mobile-phone subscribers by 2010, up from 140 at the end of 2006. "By 2010, iSuppli predicts, one of every 10 mobile phones sold will be sold in India," Rebello said. The major factor behind this growth is the advent of the ultralow-cost handsets and other low-cost phones. "For India, low-end phones will drive the next phase of growth. To serve this area, manufacturers have to drive down their phone costs," he said.

The impact of low-cost phones extends far beyond the Indian market, according to Ford. He says that mass-market handsets and ultralow-cost handsets are driving the growth of the mobile-phone market. Because of these factors, ultralow-cost-handset phones have become an area of greater focus for wireless-handset OEMs. However, a challenge for these OEMs is defining these handsets and their features. "The official definition of an ultralow-cost handset is a phone with less than $30 cost," Ford said. "Manufacturers can now take costs below that figure. There have been reports of phones with manufacturing costs less than $20, and, just last week, Motorola [www.motorola.com] was discussing a $15 product. But what are these products like, and what features will they have? You can miss the market by aiming too low. What is the magic price point and feature set that can bring in new subscribers and increase the reach of wireless while not undercutting the market?" Companies that can successfully balance these considerations will be the winners in this market, Ford said. The company predicts that ultralow-cost handsets will rise to account for more than 9% of total mobile-phone units produced in 2010, up from less than 1% in 2006.

—by Vinod Kataria, *EDN Asia*

▶**iSuppli**, www.isuppli.com.

12.15.06

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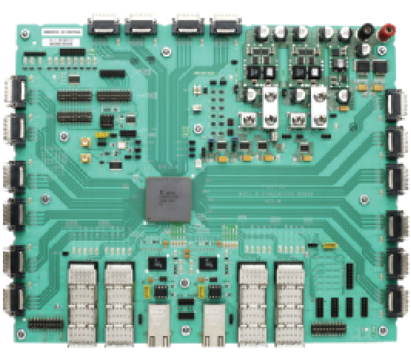

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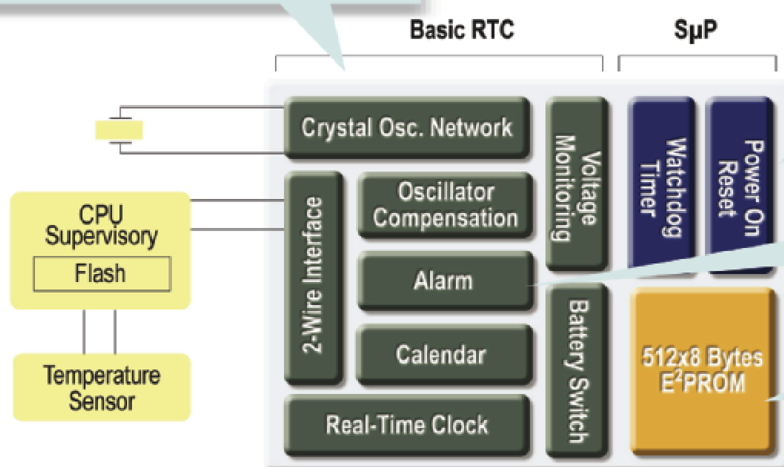

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800nA General Purpose Real-Time Clock Selector Table

	Int. E²PROM (Bytes)	Alarm	CPU Sup.Fx's POR	Wdg Timer	$\overline{IRQ}$	F_{OUT}	V_{TRIP} for Rest/Bat Switch	Package
ISL12026	512 X 8	2	N	N		$\overline{IRQ}$/F_{OUT}	5 Sel. (2.63V to 4.64V)	8-Ld SO/TSSOP
ISL12027	512 X 8	2	Y	Y		$\overline{RESET}$	5 Sel. (2.63V to 4.64V)	8-Ld SO/TSSOP
ISL12028	512 X 8	2	Y	Y		$\overline{IRQ}$/F_{OUT}	5 Sel. (2.63V to 4.64V)	14-Ld SO/TSSOP
ISL12029	512 X 8	2	Y	Y		$\overline{IRQ}$/F_{OUT}	5 Sel. (2.63V to 4.64V)	14-Ld SO/TSSOP

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BY BONNIE BAKER

What's a little glitch among friends?

You can ignore the glitch-impulse area that occurs at the output of DACs during code transition in most systems. However, in a control loop, this DAC idiosyncrasy may have a negative effect. You would think that a transition from one bit to the next with a DAC would go smoothly. After all, the voltage-out difference of two consecutive codes from a DAC is equivalent to a mere least-significant bit.

The glitch-impulse area occurs during the DAC's output-voltage-transition region as it switches from one code to another. A 16-bit DAC code transition from 8001h to 8000h produces an imperceptible glitch at the voltage-output terminal because few switches are internally changing in the DAC. If the same 16-bit DAC switches from 8000h to 7FFFh, or half the full-scale output voltage, the output-glitch impulse becomes noticeable to the extent that it appears as if the DAC is momentarily nonmonotonic. Secondary glitches occur around one-fourth full-scale and three-fourths full-scale voltages. **Figure 1** shows an example of the output-glitch impulse with a major code transition at half the full-scale of a 16-bit DAC.

DAC glitches are a product of capacitive-charge injection from the internal gates and asynchronous gate switching. The DAC glitch manifests itself with two lobes (**Figure 2a**) if there is charge injection across the parasitic capacitance of the switching gates. Typically, R2R-ladder DACs have a two-lobe glitch impulse. A second type of glitch is the single-lobe glitch impulse (**Figure 2b**). A single-lobe glitch, which DACs with a string topology usually produce, results from asynchronous switching of several internal DAC gates.

In control systems, the DAC glitch impulse from major code transitions confuses the loop by momentarily sending an erroneous output-voltage signal. If the control system is fast enough to respond to this glitch, the circuit may oscillate. You can try to reduce the impact of this glitch impulse by using a lowpass filter at the output of the DAC. However, although a lowpass filter reduces the glitch impulse amplitude, it increases the glitch time. For example, the glitch-impulse response of the 16-bit DAC in **Figure 1** is equal to 96 nV-sec, with peak voltage of 75 mV and duration of 1.6 µsec. You can filter this glitch impulse so that the peak voltage is 37.5 mV, but the duration of the glitch impulse is now 3.2 µsec. You can also implement sampling circuitry on the output of the DAC, timing it with DAC conversions. This technique may work for lower-resolution DACs; however, the sampling mechanism may create more problems by adding analog errors and conversion time. The best way to overcome larger glitch impulses is to select a string-DAC with lower glitch-impulse errors from the start. **EDN**

Bonnie Baker is a senior applications engineer at Texas Instruments. You can reach her at bonnie@ti.com.

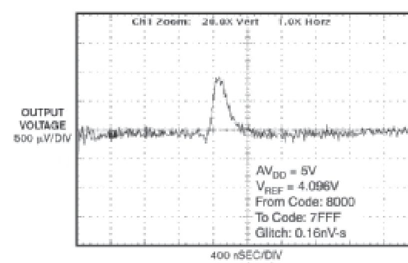

Figure 1 Glitch impulses are visible when an LSB step occurs and all the DAC codes are changing.

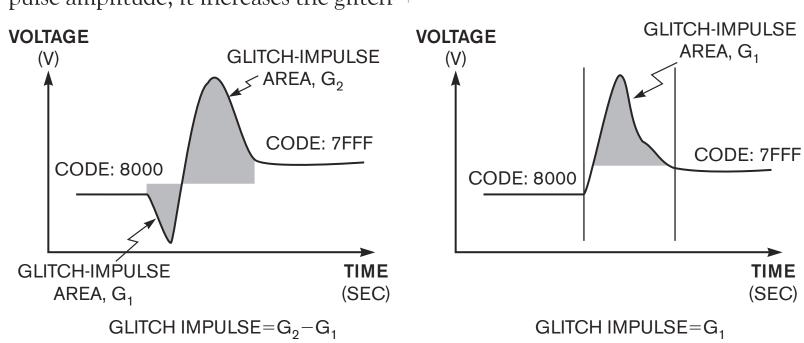

Figure 2 Glitch impulses produced by R2R DACs (a) produce two regions of code-transition error. In this situation, subtract the positive glitch impulse (G_2) from the negative glitch impulse (G_1). String DACs (b) produce glitch impulses, in turn producing one region of overshoot.

Delta-Sigma ADCs

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Automatic Calibration of External Components

The LTC®2449, an 8kHz, 16-channel delta-sigma ADC, provides high resolution systems designers with a dramatic improvement in accuracy, precision and drift. The device reduces the cost and increases the performance of precision designs by automatically calibrating and removing offsets and drifts from the entire external analog signal chain. The LTC2449's new multiplexer architecture allows external signal chain components to be included within the calibration loop of the ADC, figure 1. The converter continuously measures and automatically eliminates all offset and drift errors of external amplifiers, filters and other signal conditioning circuits right up to the sensor output. This results in a completely calibrated system, which yields outstanding precision without the need for expensive precision components or complex system hardware and calibration routines.

The flexible input multiplexer allows any combination of 16 single-ended or eight differential inputs to be accurately digitized. The fast 4kHz conversion rate, combined with the patented No Latency Delta Sigma™ architecture, allows all 16 channels to be scanned in 4msec without digital

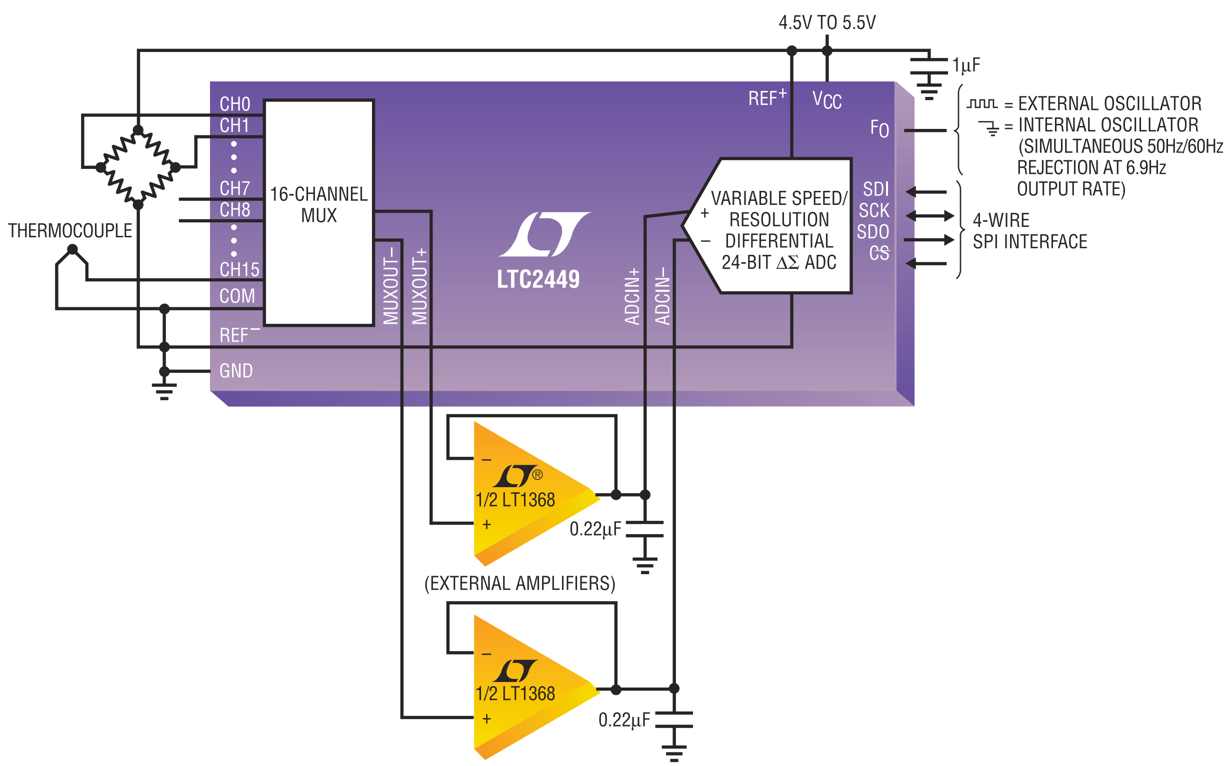

Figure 1. LTC2449 with external buffers that are automatically calibrated

Delta-Sigma ADCs

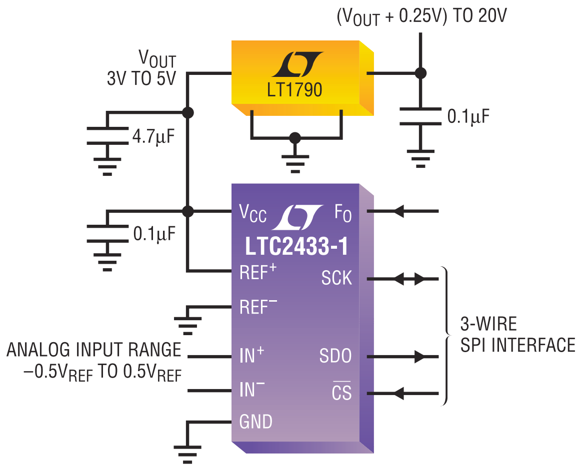

Figure 2. Low Cost, Ideal 16-Bit ADC

filter settling problems inherent in other delta sigma converters.

A programmable filter enables designers to tailor 20 different speed/resolution combinations to individual channels. For low frequency sensors such as RTDs, thermocouples, and strain gauges, the ADC provides 200nV noise, 500,000 counts on a ±50mV sensor output (or 25 million counts on a full scale input) and simultaneous 50Hz and 60Hz line frequency noise rejection. For high-speed sampling, the ADC provides over 17 effective bits at 8kHz output rates.

For reduced channel count applications, the pin-compatible LTC2445 offers four differential or eight single-ended inputs. In applications not requiring the signal chain calibration features, the pin-compatible LTC2444/LTC2448 are available.

All four of these converters are offered in a 38-pin QFN package, a 5mm×7mm footprint. Overall, this family provides designers of precision instrumentation with a flexible yet easy to use high resolution ADC.

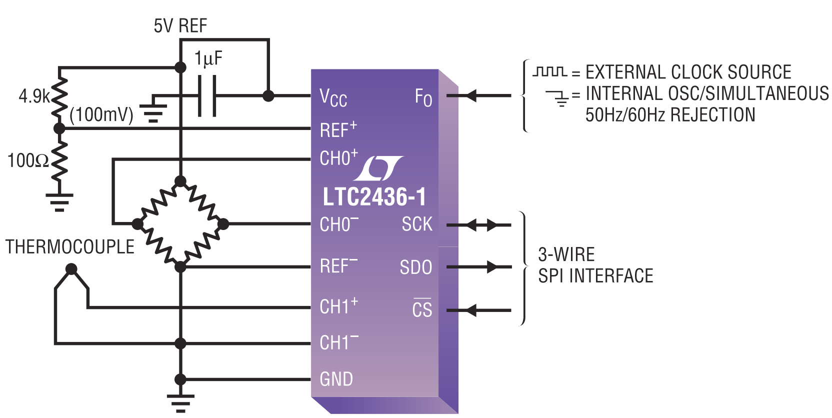

Figure 3. Two-Channel Differential 16-Bit ADC Automatically Alternates Channels

Low Cost, 16-Bit Delta Sigma ADCs Provide Ultralow Noise

Building on its extensive family of 24-bit and 20-bit No Latency Delta Sigma ADCs, Linear Technology now offers a low noise, low cost, ideal 16-bit series that is pin-compatible with the higher resolution versions. The LTC2433-1 (1-channel), LTC2436-1 (2-channel) and LTC2439-1 (8-channel) offer exceptionally low noise performance, enabling 16-bit performance independent of V_{REF}. Linear Technology's proprietary architecture guarantees modulator stability and lock-up immunity under any output and reference conditions. This allows a wide reference range of 100mV to 5V. A 100mV reference resolves a differential input signal of ±50mV to 16-bits without the need of a programmable gain amplifier, allowing direct digitization of many sensors. Even with the small V_{REF}, the common mode input range extends between ground and V_{CC}.

LTC2433-1 – Single Channel

In a 10-pin MSOP package, the LTC2433-1 provides a differential input and a differential reference, yet can fit within the shell of a sensor or transducer. The LTC2433-1 is not only small, but also has just 1.45µV RMS noise for just $1.95 each in 1,000-piece quantities.

LTC2436-1 – Two Channels

The LTC2436-1 can accept two differential inputs, which are converted alternately without being programmed (ping-pong), greatly simplifying programming and communication over an isolation barrier. The full-scale input spans $-0.5V_{REF}$ to $0.5V_{REF}$, allowing the reference voltage to be

anywhere between 0.1V and V_{CC} for flexible ratiometric and remote sensing configurations. Since the noise level is only 800nV and independent of V_{REF}, input resolution increases by simply lowering the reference voltage. The robust analog inputs span the entire operating range of the device, 0V to V_{CC}. This device is offered in the narrow 16-pin SSOP and pricing starts at $2.45 each in 1,000-piece quantities.

LTC2439-1 – Eight Channels

In the narrow 28-pin SSOP, the LTC2439-1 offers up to eight differential or 16 single-ended inputs or user-selectable combinations. It operates from 2.7V to 5.5V and

Extensive Family of Easy to Use ADCs

Linear Technology pioneered the development of easy to use delta sigma ADCs. Leveraging innovations that simplify hardware design and code development, these ADCs provide extremely low noise. Key innovations include:

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- **Near Zero Drift**
- **0 to V_{CC} Common Mode Range**
- **Accurate Readings Below Ground (Live at Zero)**
- **High Accuracy On Chip Tuned Oscillator**
- **Tiny Packages**
- **Variable OSR**
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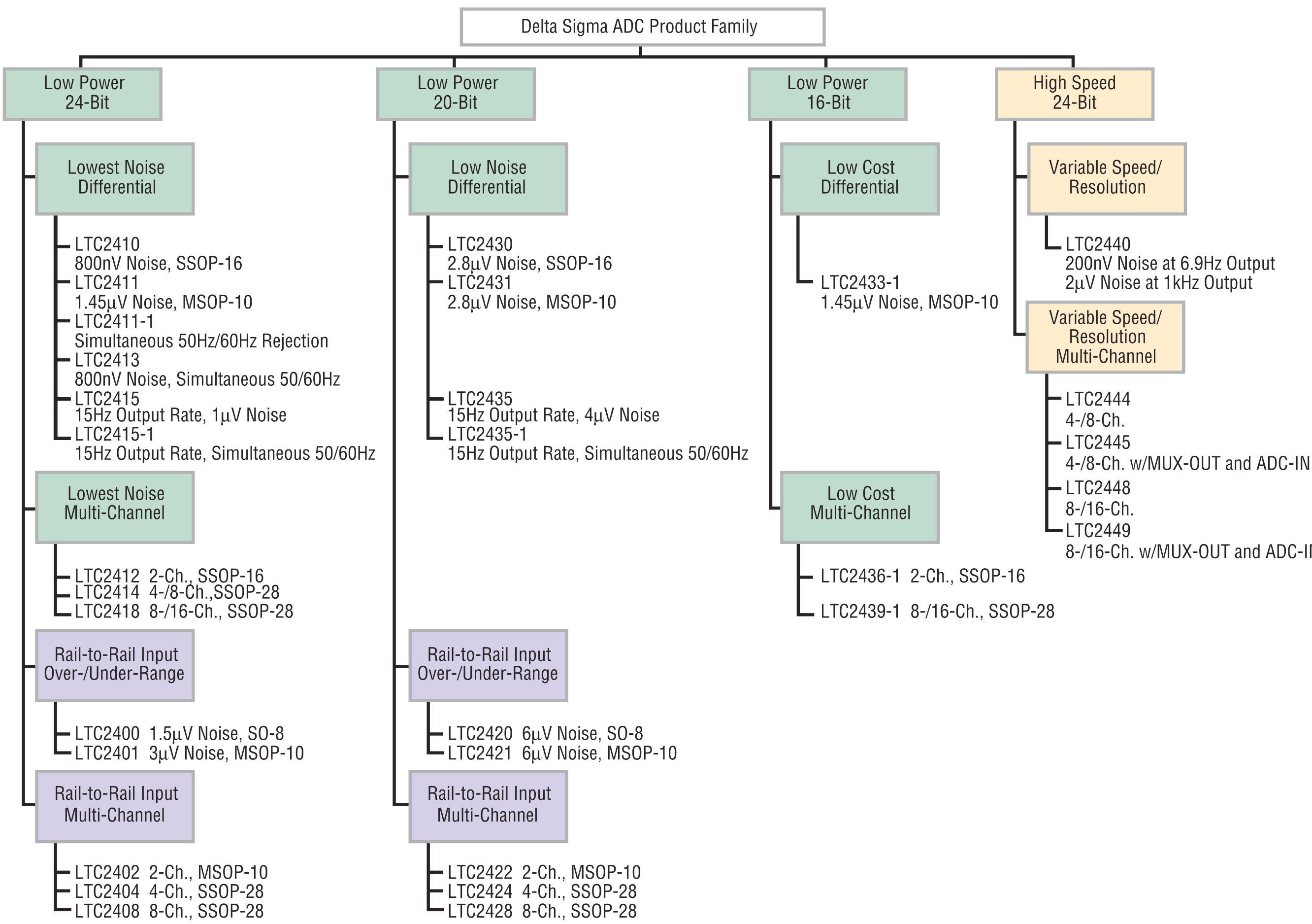
- **Wide Rejection Notch**
- **Low Power**
- **Guaranteed Modulator Stability and Lock-Up Immunity**
- **Flexible Analog Inputs**



LINEAR TECHNOLOGY

includes an integrated oscillator, 1.25LSB INL and 1µVRMS noise. Pricing starts at $3.75 each in 1,000-piece quantities.

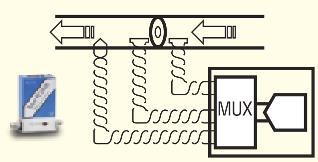
Each device performs transparent offset and full-scale calibration on every conversion to provide extremely low offset and full scale errors with near-zero temperature drift. The proprietary no latency architecture allows single cycle settling. This avoids the need to discard data until the digital filter has settled, as required with other high resolution ADCs. Transparent calibration and single cycle settling dramatically simplify system software. A highly accurate on-chip oscillator eliminates the need for costly external frequency setting components such as crystals or external clock sources.

This low cost family combines ultralow noise, ease of use, simultaneous 50Hz/60Hz rejection and the ability to output data as fast as 100Hz with 16-ENOBs (Effective Number of Bits). For low cost, precision instrumentation from one channel to 16, Linear Technology has the ideal solution.

Ideal Configurations for Many Applications

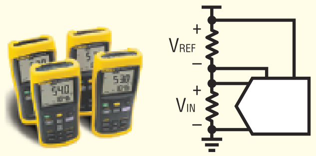
Whether you need to digitize sensors with negative offset or a dozen transducers, there is a Linear Technology converter for the task. Every converter has a tuned internal oscillator and every converter offers an auto-calibrated, highly accurate output without latency. This family of ADCs covers a range from low cost 16-bit converters to extremely low noise 24-bit converters with inputs ranging from one to 16 channels.

Flow



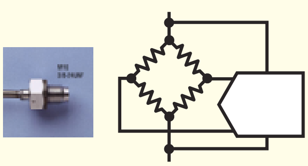
- Fast Multi-Channel with No Latency
- Up to 4kHz Multiplex Rate
- Variable Speed/Resolution
- Direct Digitization without PGAs

Temperature



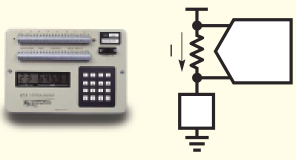
- Direct Interface to RTDs
- Measure Negative Voltages
- Noise as Low as 200nV
- Immeasurable Drift

Pressure



- Low Power, Wide Supply Range
- Super-Tiny Packages
- Very Low Noise

Voltage/Current



- Wide Dynamic/Common Mode Range
- Noise as Low as 200nV
- Measure Micro-Volts on Volts
- Sense Micro-Amps on Milli-Ohms

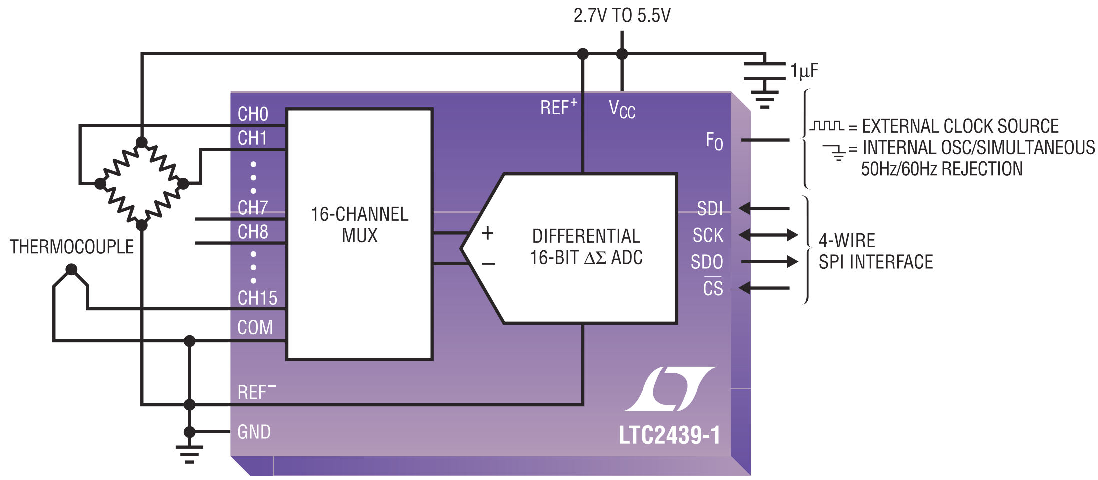


Figure 4. Read up to 16 inputs with one 16-bit ADC

LINEAR TECHNOLOGY

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As the calendar nears January, popular culture inevitably begins to cough up countless "best-of" lists, covering frivolous topics from reality TV to celebrity hairstyles. In an effort to counteract this tide of inanity, we at *EDN* proudly offer you something of substance: A Hot 100 list built by and for electronics engineers.

Our editors mercilessly cull the herd of new-product announcements they see during the year, resulting in this distillation of the most innovative and significant offerings. You'll find process technologies, power sources, storage devices, processors, IP (intellectual-property) cores, communication controllers, test instruments, embedded boards, EDA tools, and more. If they advanced the state of the art in electronics, they're here. And not a movie star in sight.

HOT 100 products

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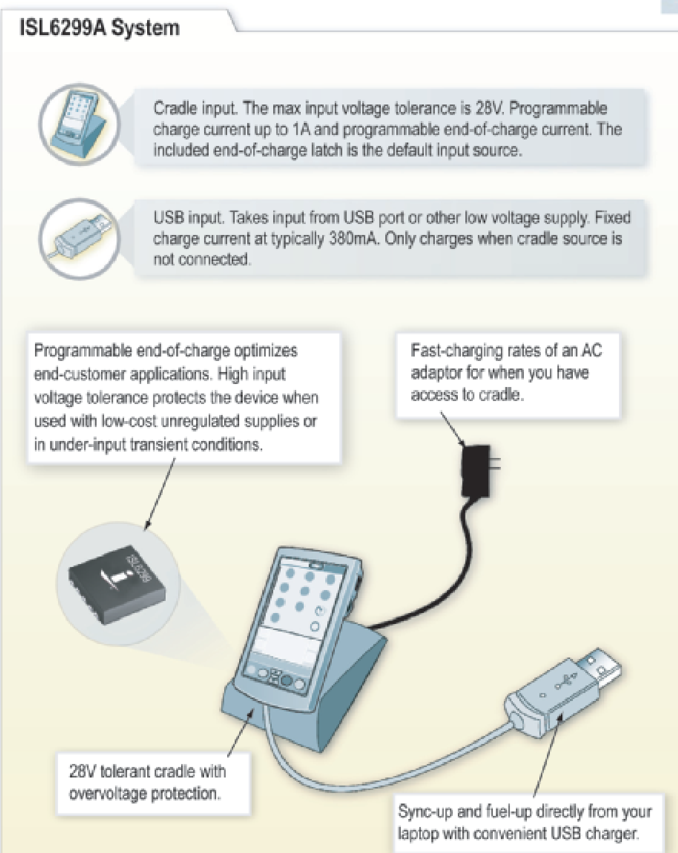
Intersil's ISL6299A is a fully integrated low-cost Li-ion or Li-polymer battery charger that accepts both USB port and desktop cradle chargers.

The ISL6299A is a low component count solution that features programmable cradle charge current, charge indication, adapter present indication, and programmable end-of-charge (EOC) current with latch. All these advanced features, along with Intersil's Thermaguard™ technology for an added measure of thermal protection, are delivered in a single 3x3 mm DFN package.

ISL6299A System



ISL6299A Key Features:

- Dual-input charger for single-cell Li-ion/polymer batteries for cradle and USB
- Low component count
- Integrated pass element
- Fixed 380mA USB charge current
- Programmable cradle charge current
- Charge current Thermaguard™ for thermal protection
- 28V maximum voltage for the cradle input
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- V_{OUT3}: **Adjustable, 0.8V to V_{IN}**

Synchronized 180º out-of-phase, reducing the RMS input current and ripple voltage.

Triple Output PWM Controller
4.5V to 5.5V or 5.6V to 24V Input Voltage

- V_{OUT1}: **Adjustable, 0.8V to V_{IN}**
- V_{OUT2}: **Adjustable, 0.8V to V_{IN}**
- V_{OUT3}: **Adjustable, 0.8V to V_{IN}**

An adjustable overcurrent protection circuit monitors the output current by sensing the voltage drop across the lower MOSFET.

Dual Output PWM Controller
4.5V to 5.5V or 5.6V to 24V Input Voltage

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- V_{OUT3}: **Adjustable, 0.8V to V_{IN}**

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LOW COST, PLENTIFUL, CLEAN, AND, IN ALL OTHER RESPECTS, "GREEN." THESE WORDS DESCRIBE WIND POWER IN A NUTSHELL. SO, WHY IS IT SO UNPOPULAR? THE DEVIL IS IN THE DETAILS, ALONG WITH OUR RELUCTANCE TO ADOPT AN UNKNOWN TECHNOLOGY. WITH FOSSIL-FUEL PRICES ON THE RISE, THEIR SUPPLY INCREASINGLY UNSTABLE, AND GLOBAL-WARMING EFFECTS GROWING, HOWEVER, THE WIND-TURBINE ALTERNATIVE IS GARNERING OVERDUE ATTENTION.

CUTTING THE CARBON-ENERGY CORD: IS THE ANSWER BLOWIN' IN THE WIND?

BY BRIAN DIPERT • SENIOR TECHNICAL EDITOR

The debate on global warming is over, according to *Scientific American* (**Reference 1**). With those no-holds-barred words, the respected journal introduced the theme of its September 2006 special issue, "Energy's Future: How to Power the Economy and Still Fight Global Warming." Diminishing but still lingering debate within the scientific community hasn't completely settled the question of whether—and, if so, to what degree—increased carbon dioxide and other greenhouse-gas concentration in the earth's atmosphere have caused global warming (**Figure 1**). But *Scientific American*'s Special Projects Editor Gary Stix seems convinced that a material link exists: "Present levels of carbon dioxide—nearing 400 ppm in the earth's atmosphere—are higher than they have been at any time in the past 650,000 years and could easily surpass 500 ppm by 2050 without radical intervention. ... Almost all of the 20 hottest years on record have occurred since the 1980s. No one knows exactly what will happen if things are left unchecked—the exact date when a polar ice sheet will complete a phase change from solid to liquid cannot be foreseen with precision. ... But no climatologist wants to test what will arise if carbon-dioxide levels drive much higher than 500 ppm" (**Reference 1**).

Even if you're not a fan of the "fossil-fuels-equal-global-warming" theories, plenty of other good reasons exist to seriously consider weaning yourself from carbon-based—that is, coal, natural-gas, and petroleum—economy. A simple visit to the local gas station will suffice as motivation. First, let's analyze the supply-side reasons for the recent price increases. In the near term, the unstable political situation in the Middle East, home to an estimated two-thirds of the world's oil reserves, has disrupted supply lines. In the longer term, an increasing number of analysts are warning that we're nearing the Peak Oil threshold—that is, the point beyond which, the Hubbert Peak Theory predicts, earth's oil production will begin to decline (**Reference 2**). We won't immediately feel the impact of this decay; "Even if oil production

peaks soon—a debatable contention given Canada's oil sands, Venezuela's heavy oil, and other reserves—coal and its derivatives could tide the earth over for more than a century," says *Scientific American*. But beyond Peak Oil, whenever it happens, the supply decline will be unrelenting.

The magazine goes on to address demand: "The United States holds less than 5% of the world's population but produces nearly 25% of carbon emissions." (Note: The US population passed the 300 million threshold just two months ago.) And what about demand trends in the future? "The torrid economic growth of China and India will elicit calls from industrial nations for restraints on emissions, which will again be met by even more adamant retorts that citizens of Shenzhen and Hyderabad should have the same opportunities to build their economies that those of Detroit and Frankfurt once did." Infrared-radiation retention and supply/demand anxieties combine with a third primary carbon-based-fuel concern: pollution. As *The New York Times* points out, "Coal ... is causing acid rain and respiratory ailments while contributing to global warming. China accounted for 79% of the world's growth in coal consumption last year, and India used 7% more" (**Reference 3**).

In the face of such gloomy news, energy-redirection efforts around the world are increasing in number and pace, with two primary objectives: the near-term goals of minimizing the emissions of carbon-centric-fuel sources and minimizing worldwide energy demands and the long-term goal of developing alternatives to carbon-based energy. *Scientific American*'s article lists five high-confidence candidates, along with a host of tier-two alternatives: nuclear power, solar cells, bio-fuels, hydrogen, and wind turbines. Wind power is a topic near and dear to the hearts of many in Silicon Valley, who live and work near California's largest wind-farm collective, Altamont Pass, which California built after the 1970s energy crisis and which state tax credits funded (**Figure 2**). Southern California residents may be more familiar with the state's two other large wind farms: San Gorgonio Pass near Palm Springs and Tehachapi Pass, which links the San Joaquin Valley and the Mojave Desert.

AT A GLANCE

- Greenhouse-gas-induced global-warming worries aren't the only reasons to consider a power-grid shift to wind power.
- Thorough wind-farm-location planning is key, both for maximizing efficiency and power output and for addressing wildlife-safety concerns.
- Horizontal- and vertical-axis wind turbines both have advantages and disadvantages; second-tier design trade-offs also bear consideration.
- Wind's unpredictable nature forces utility operators to think differently about power generation.
- Sea- and high-altitude-based turbines present different sets of benefits and complications, and homeowners can also exploit wind's power potential.

Wind power isn't a California-only phenomenon; the largest stand-alone farm in the United States lies along the Oregon/Washington border, and, while traveling this year, I observed a number of massive wind turbines on both sides of Minnesota's Highway 90, as well as their predecessors, windmills, all across the country. Wind power isn't a United States-only occurrence, either; according to Wikipedia and other sources, 69% of the world's end-of-2005 wind-power production occurred outside the United States (**Reference 4**). Germany alone produced 32% of the world's 58,982 MW of wind energy, and wind generated 6% of Germany's electricity, versus 1% of the world's electricity and 0.4% of electricity in the United States, representing roughly 1.6 million homes' demand. Denmark's wind-energy generation was only fifth in the world in absolute capacity, yet it satisfied more than 20% of the energy demands of its citizens, the highest percentage in the world. Between Germany with 18,428 MW in 2005 and Denmark with 3128 MW in absolute capacity were Spain with 10,027 MW, the United States with 9149 MW, and India with 4430 MW.

At first glance, wind power might seem to be a "perfect" energy source; It is clean, greenhouse-gas-mitigating, abundant, infinitely renewable, domestically produced, low-priced in many locations, widely distributed, and supportive of rural economies. But, like any other technology, it involves trade-offs. A combination of technical, economic, political, and aesthetic factors has muted

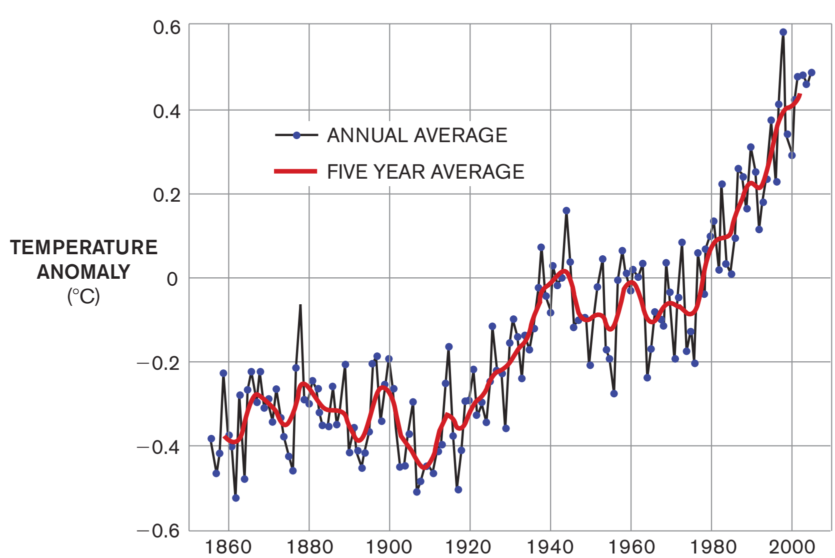
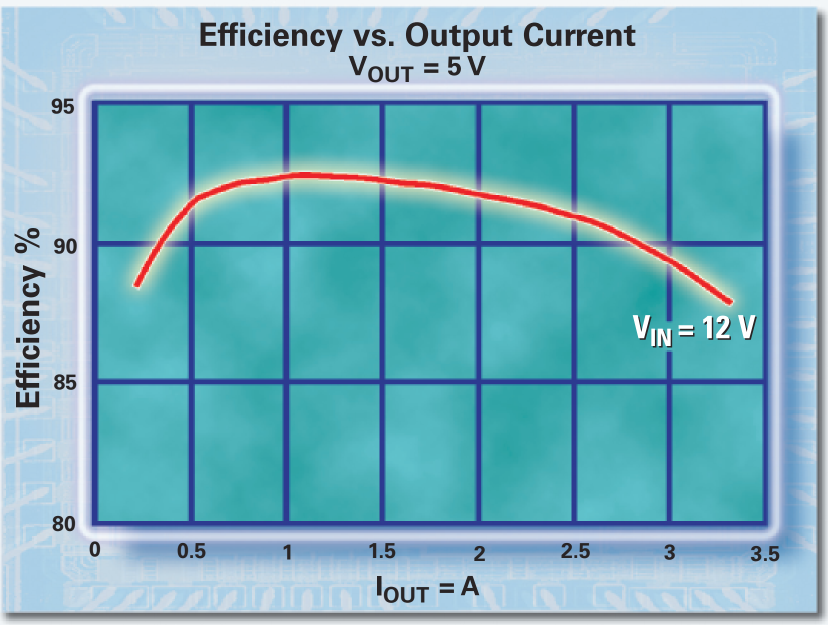


Figure 1 In some graph versions, this 150-year-spanning "hockey stick" of global temperatures, based on instrument-measurement records, further expands into the past using "proxy" records, such as, according to Wikipedia, the width of tree rings; the amount of snowfall over glacial sites; the isotopic composition of snow, corals, and stalactites; the time of crop harvests; the tree line in various locations; and other historical records (courtesy the Climatic Research Unit of the University of East Anglia and the Hadley Centre of the UK Meteorological Office).

3-A, Easy-to-Use, 36-V Input Step-Down Converter



▶ TPS5430 Applications

- Set top boxes and digital television
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▶ TPS5430 Features

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3-A SWIFT™ Devices

Specifications	TPS5430	TPS54350	TPS54310	TPS54317
V_{IN} Range	5.5 V to 36 V	4.5 V to 20 V	3.0 V to 6.0 V	3.0 V to 6.0 V
V_{OUT} Min	1.22 V	0.9 V	0.9 V	0.9 V
Switching Frequency Max	500 kHz	700 kHz	700 kHz	1.6 MHz
Price 1k (US $)	$1.75	$2.05	$2.35	$2.50
Package	HSOIC-8	HTSSOP-16	HTSSOP-20	QFN-24

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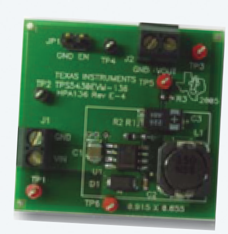

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Figure 2 You'll find the three largest wind-farm collectives in California on Altamont Pass, San Gorgonio Pass, and Tehachapi Pass.

the initial enthusiasm for wind power that nations exhibited at the height of the 1970s OPEC (Organization for the Petroleum Exporting Countries) crisis. But with enough time, effort, and money, countries can surmount most if not all of wind power's issues. And, as the world grapples with another cyclical spike in carbon-based fuel prices, the motivation to surmount those issues is once again on an upward climb.

LOCATION, LOCATION, LOCATION

The three most important factors in real-estate value—location, location, location—also hold true for wind energy. A turbine's location is critically important to its subsequent power-generation success. As Wikipedia states, you must pay attention to "micro-siting"—the exact positions of the turbines—because a difference of 30m can sometimes mean a doubling in output. The US Department of Energy developed **Figure 3**, which shows wind-energy potential across the United States. Specifically, this data targets terrestrial-based wind turbines; the picture differs dramatically when you broaden the options to include ocean-based and high-altitude wind-generation equipment (see **sidebars** "Up in the air" and "Out of sight, out of mind?"). A historical rule of thumb suggests that a site isn't ideal for wind-farm usage unless it exhibits average wind speeds of 10 mph or higher, but turbine advancements are steadily lowering the palatable wind-speed threshold (see **sidebar** at "More at EDN.com").

Altamont Pass, one of the earliest wind farms in the United States, provides a case study of both location strengths and location shortcomings. Wikipedia points out that "under hot inland (Central Valley) conditions, a thermal low is developed that brings in cool coastal marine air, driving the tur-

UP IN THE AIR

In its introduction to the topic of wind power, Wikipedia notes that, "An estimated 1 to 3% of energy from the sun that hits the earth is converted into wind energy. This is about 50 to 100 times more energy than is converted into biomass by all the plants on earth through photosynthesis. Most of this wind energy can be found at high altitudes where continuous wind speeds of over 160 km/h (100 mph) occur." And, in its September 2005 edition, which classifies high-altitude wind-energy generation as a Plan B technology, *Scientific American* notes that according to New York University physicist Martin I Hoffert, "roughly two-thirds of the total wind energy on this planet resides in the upper trophosphere, beyond the reach of today's wind farms" (Reference A).

Here's more from *Scientific American*: "Ken Caldeira of the Carnegie Institution of Washington once calculated how wind power varies with altitude, latitude, and season. The mother lode is the jet stream, about 10,000 meters (33,000 feet) up between 20 and 40 degrees latitude in the Northern Hemisphere. In the skies over the United States, Europe, China, and Japan–indeed, many of the countries best prepared to exploit it–wind power surges to 5000 or even 10,000 watts a square meter. The jet stream does wander. But it never stops."

Atmospheric-wind-farm architects would need to tether an aerial turbine to the ground, both to hold it in position and to facilitate power transfer to terrestrial stations. To enable the turbine to rise to and maintain altitude, researchers have proposed three primary power schemes: adjustable-pitch counter-rotating blades; helium; and solar cells, which batteries would supplant for overnight and cloudy-weather operation. Maintenance costs, such as periodically refilling the helium, and durability in the face of turbulence, wind gusts, lightning strikes, moisture, and other factors are practical issues that energy providers must address before they can tap the tremendous energy potential of the trophosphere. Also, although high-altitude wind farms consume much less ground area than their terrestrial counterparts, they require civilian- and military-aviation-agency-regulatory approval.

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A Gibbs, Wayne B, "Plan B for Energy," *Scientific American*, September 2006, pg 106.

bines at a time of maximum electricity demand" (**Reference 5**). In an analogous experience, while driving from Palm Springs to Los Angeles in late May, I struggled against the resistance of an extremely powerful wind stream; the midafternoon sun was heating the high desert to the east, while a cool, wet fog swathed the Los Angeles Basin on the west side of San Gorgonio Pass. Beyond exploiting air pressure and temperature variance, both passes' turbine farms, like the one at Tehachapi Pass, also take advantage of another Wikipedia-described wind phenomenon; "Onshore turbine installations tend to be on ridgelines … to exploit so-called topographic acceleration. The hill or ridge causes the wind to accelerate as it is forced over it. The additional wind speeds gained in this way make large differences to the amount of energy that is produced."

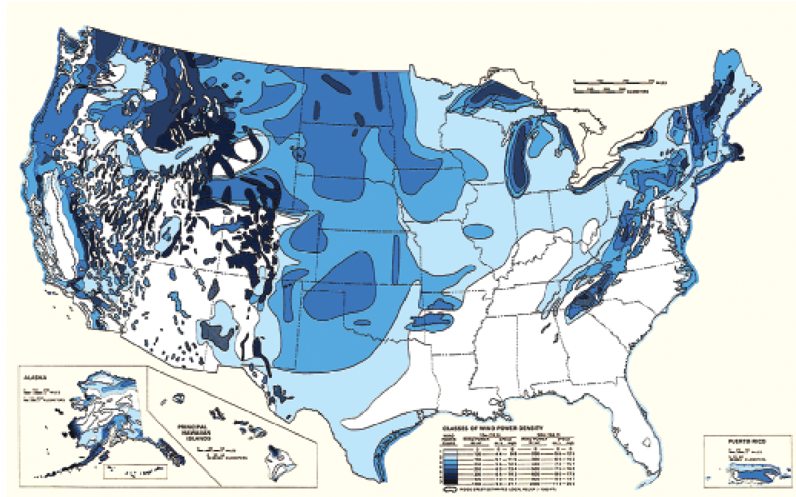

Figure 3 Areas of the United States with Class 4 and higher wind ratings are suitable for farming in conjunction with advanced turbine technology (courtesy United States National Renewable Energy Laboratory).

Yet Altamont Pass isn't a perfect site. Part of the reason is weather-related. According to Wikipedia, the area sometimes exhibits an inland high-pressure condition, meaning that the entire region can be both hot and windless. At these times, backup natural-gas-powered turbine plants must pick up the slack. Another part of the reason that Altamont Pass is imperfect is that birds and bats can become caught and die in the turbine rotors. This problem is the crux of many environmentalists' uneasy embrace of wind power, but careful site selection can minimize it. In the *IEEE Institute*, J Charles Smith, executive director of the Utility Wind Integration Group, notes of Altamont Pass that,

OUT OF SIGHT, OUT OF MIND?

I admit it: I find wind farms and the turbines contained within them attractive. (Granted, though, I don't live near one.) They mesmerize me every time I drive by or through Altamont Pass. But not everyone agrees with me, thereby explaining part of the appeal of offshore wind-farm alternatives. Their distance from population centers also mitigates any potential noise concerns and, because the winds are stronger and obstacles are fewer at sea, the turbines can be shorter (as measured from the water's surface) than their onshore alternatives.

The continuous presence of strong, sustained winds is a key advantage of offshore wind farms. Stephen Connors, the director of the Massachusetts Institute of Technology's (www.mit.edu) Analysis Group for Regional Energy Alternatives at the Laboratory for Energy and the Environment, points out that, 100 miles off the northeast coast of the United States, the wind is 50% stronger to twice as strong as it is onshore (Reference A). But the news isn't all good; marine environments, with their caustic salt and moisture, extremes of temperature, and wind gusts, can impact turbine reliability and usable life. And there's the issue of how to get the power back to shore; the farther the wind farm is from the coastline, the more expensive the undersea cable.

Finally, there's the practical issue of how to solidly secure the turbines in inherently nonsolid water. In countries such as Denmark and Scotland, which have long extended continental shelves, it's possible to secure wind turbines to the sea floor; a prototype 5-MW turbine 10 miles off the coast of Moray Firth, Scotland, for example, sits in 150 ft of water. The US coastline drops off much faster, however, and for that reason MIT has developed a 5-MW prototype in which the turbine tower connects to a 100-ft-diameter underwater platform, which then attaches to concrete anchors stretching up to 650 ft farther to the ocean floor.

And, if even the thought of offshore turbines sticking out of the water is aesthetically unpleasant to you, consider this: Several companies are developing turbines that locate below the water and tap into the periodic tide flow for energy generation. However, the potential impact on marine life, analogous to wind turbines' prospective effect on avian populations, is a perhaps obvious hurdle to the practical implementation of such a scheme.

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A Stauffer, Nancy, "Deep-sea oil rigs inspire MIT designs for giant wind turbines," MIT Laboratory for Energy and the Environment, Aug 29, 2006, web.mit.edu/newsoffice/2006/wind.html.


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"This wind farm used old high-speed turbines right in a flyway, surrounded by open scrub grass with lots of ground squirrels to attract raptors. Now, we know more about avian flyways; we study each site for about a year" (**Reference 6**).

What other areas make good locations for wind farms? Wikipedia points out that "Seashores also tend to be windy areas and good sites for turbine installation, because a primary source of wind is convection from the differential heating and cooling of land and sea over the course of day and night. Winds at sea carry somewhat more energy than winds of the same speed in mountainous areas because the air at sea level is more dense." Hilltops and seashores might be ideal locales from a wind-profile standpoint, but they're anathema to folks who see wind turbines as eyesores. Looking again at **Figure 3**, you'll note that plenty of the ideal wind-generation sites in the United States are removed from large population centers. The US Department of Energy estimates that, by harnessing just 6% of the US land area for wind energy, it would be possible to supply 1.5 times the country's current electricity-consumption needs, thereby opening the door to further pollution- and greenhouse-gas-reducing steps, such as a wholesale population conversion to electric vehicles (**Reference 7**). Unfortunately, though, locating wind farms far away from population centers increases the cost and complexity of transferring generated power to those population centers.

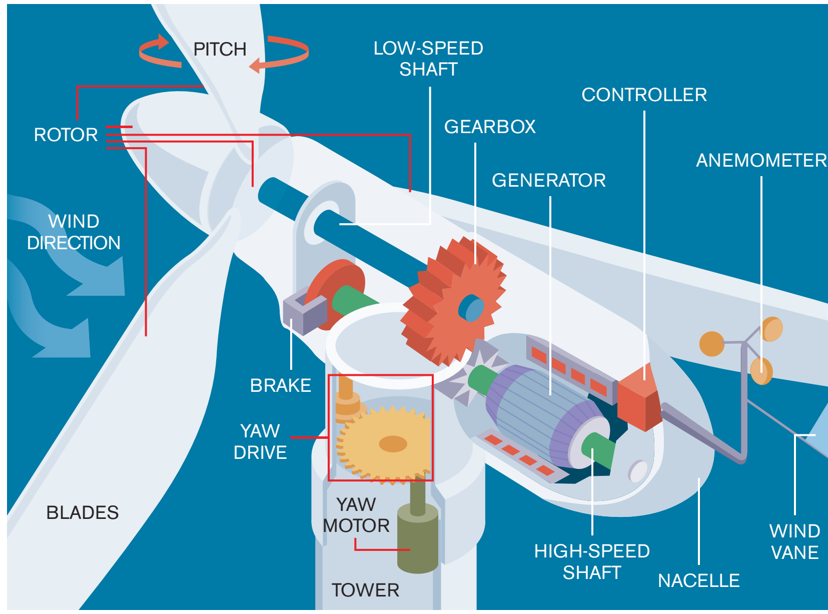

Figure 4 A traditional upwind horizontal-axis turbine design includes, at its heart, a gearbox that translates the relatively slow blade-rotation speed to a higher speed shaft rotation suitable for electricity generation (courtesy US Department of Energy).

DIVERSE DESIGN OPTIONS

Once you find an ideal site for your wind farm, what sort of turbines should you place there? As usual, no easy answers exist, as a visit to Altamont Pass and its plethora of turbine shapes and sizes suggest. **Figure 4** shows the guts of a traditional multiblade, nacelle-housed, horizontal-axis turbine design. The gearbox translates the blades' 30- to 60-rpm rotational speed to the 1200 to 1500 rpm necessary to operate a generator. These turbines come in both downwind- and upwind-pointing variants: The upwind versions are more common, because towers produce turbulence behind them, which causes fatigue failure with downwind-turbine blades. However, the upwind versions are also more mechanically complex, each requiring a wind vane and yaw drive to keep them facing into the wind.

Your next questions are: How tall should your turbine be, and how many blades should it house? Once again, you have a number of factors to consider, which Wikipedia addresses. "The wind blows faster at higher altitudes because of the reduced influx of drag of the surface (sea or land) and the reduced viscosity of the air. The increase in velocity with altitude is most dramatic near the surface and is affected by topography, surface roughness, and upwind obstacles such as trees or buildings. Typically, the increase of wind speeds with increasing height follows a logarithmic profile that can be reasonably approximated by the wind profile power law, using an exponent of one-seventh, which predicts that wind speed rises proportionally to the seventh root of altitude. Doubling the altitude of a turbine, then, increases the expected wind speeds by 10% and the expected power by 34%."

So, the taller the turbine, the better, both because the wind is stronger and because you can make the blades longer. But the taller-is-better argument holds true only to a point. The taller the turbine, the more expensive it is to build and maintain, and, at some point, you need to worry about interfering with air traffic. Next, how many blades should the turbine have: one with counterbalance, two, three, or more? The variance in wind velocity with altitude causes the force and, therefore, torque on a horizontal-axis turbine blade to be greatest at the upper reach of its arc (**Reference 8**). The resultant cyclic twist, a reliability issue that you can design around, is worse with even-blade-count turbines, because one blade is at its maximum, or straight up, while another is at its minimum, or straight down. All other factors being equal, higher blade counts bring lower vibration intensity, generally lower noise and wear, and generally higher efficiency. On the other hand, small, high-blade-count turbines suffer decreased efficiency due to blade-to-blade turbulence effects. Also, turbine cost generally increases with increased blade count, regardless of turbine size.

Visit a wind farm, and you might also see strange-looking vertical-axis turbines, reminiscent in appearance of an eggbeater (**Figure 5**). These Darrieus or Gorlov wind turbines have higher efficiency than their horizontal-axis counterparts. The turbines' names derive from their inventors: respectively, French aeronautical engineer Georges

(continued on pg 50)

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POWER MANAGEMENT

Analog Applications Journal

BRIEF

Single-chip bq2403x charger and power-path manager charges battery while powering system

***By Jinrong Qian** • Applications Manager, Battery Management Applications*

The lithium-ion (Li-ion) battery is widely adopted in portable devices because of its high energy density on both a gravimetric and volumetric basis. Users of applications such as smartphones, PDAs, and MP3 players want to be able to operate the device from an input source without a battery. This requires a power architecture with two separate paths for device system power and battery charging, called power-path management.

Dynamic power-path-management (DPPM) battery charger

In the most commonly used battery-charging and system-power configuration, the system load is directly connected to the battery-charger output. This architecture is simple and low-cost but can cause improper charge termination and false safety-timer warnings due to ineffective control of the battery charge current.

The bq2403x family of DPPM battery chargers has a power-sharing capability of simultaneously powering the system and charging the battery. This eliminates the charge-termination and safety-timer issues, minimizes the AC adapter power rating, and improves system reliability. It also allows the system to operate while charging a deeply discharged battery.

Figure 1 is a block diagram of a simplified power-path-management battery charger. When the AC adapter is plugged in, MOSFET Q1 is used to preregulate the system bus voltage, V_{OUT}, which is higher than the maximum battery regulation voltage, V_{BAT}. This establishes a direct path from the adapter input to the system. The MOSFET Q2 is dedicated to charging the battery, so there is no interaction between the battery and the system. When a USB is present and selected, the MOSFET Q3 is fully turned on, the Q3 output provides almost the same voltage as the USB output, and the MOSFET Q2 controls the battery charging.

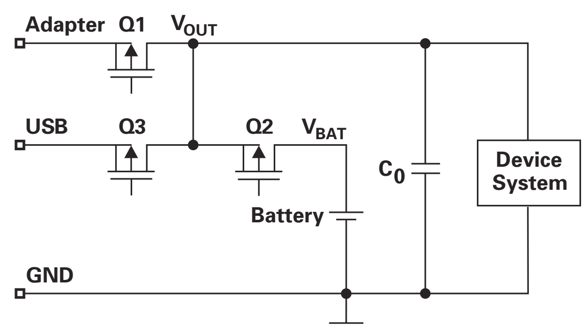

Figure 1. Simplified power-path-management battery charger

DPPM actively monitors the system bus voltage. If the system bus voltage drops to a preset value due to a limited amount of input current from the adapter or USB, the battery-charging current is reduced until the output voltage stops dropping. The DPPM control tries to reach a steady-state condition where the system gets its needed current and the battery is charged with the remaining current. Because of this, the adapter is designed based on average power from the system, not on maximum peak system power. This allows the designer to use a smaller power rating and a cheaper adapter.

Figure 2 shows a typical DPPM applications circuit. When the total current from the system and battery charger exceeds the current limit of the AC adapter or USB, the capacitors connected to the system bus start to discharge and system bus voltage begins to drop. When the system bus voltage drops to the predetermined threshold set by the DPPM pin, the charge current is reduced to prevent a system crash from overloading the AC adapter. If the system bus voltage cannot be maintained even when the charge current is reduced to 0 A, the battery will temporarily discharge and provide power to the system to avoid a system crash. This is called "battery supplement mode" and is shown in Figure 3 along with the DPPM experimental waveforms.

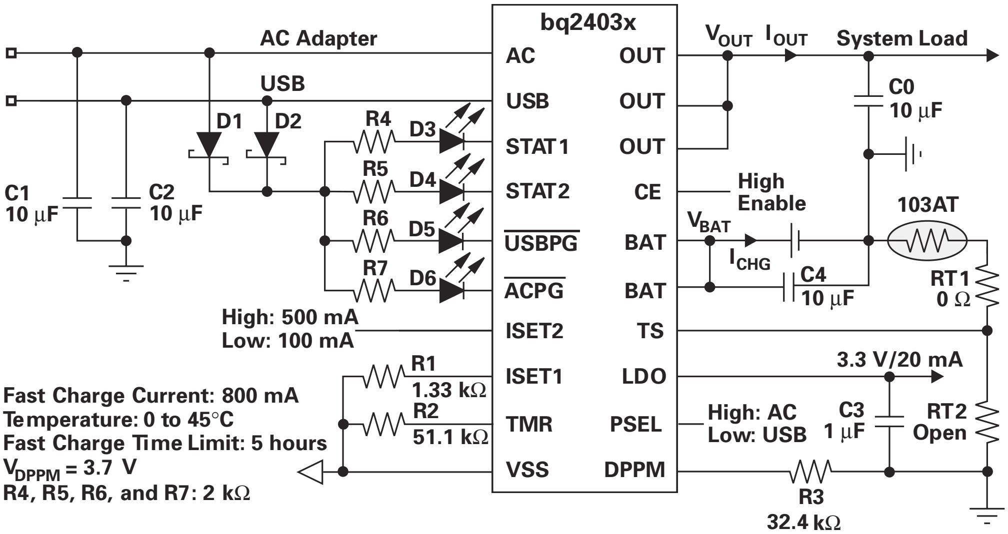

Figure 2. DPPM battery charger

The DPPM voltage threshold, V_{DPPM}, is set by resistor R3 and is typically below the regulation voltage at the OUT pin to safely keep the system operating. R3 is calculated by

$$R3 = \frac{1.15 \times V_{DDPM}}{100\,\mu A}.$$

R1 is used to set the fast charge current and is given by

$$R1 = \frac{450 \times 2.5\ V}{I_{CHG}}.$$

R2 is used to set the safety-timer value. Typically the temperature qualification for allowing an Li-ion battery to be charged is between 0°C and 45°C. RT1 and RT2 are programmed for different temperature ranges.

The battery charger can select either AC or USB power as the main power source through the PSEL pin, and maximum current is also selectable through ISET2 when the USB port is selected.

Three power MOSFETs and a power controller are integrated in a thermally enhanced 3.5 x 4.5-mm QFN package. A thermal regulation loop reduces the charge current to prevent the silicon temperature from getting higher than 125°C. Whenever the charge current is reduced either by active thermal regulation or by active DPPM, the safety-timer duration is automatically increased to prevent an unexpected false safety-timer warning. Charge termination is also disabled when either DPPM or the thermal regulation loop is active. This approach prevents false charge termination.

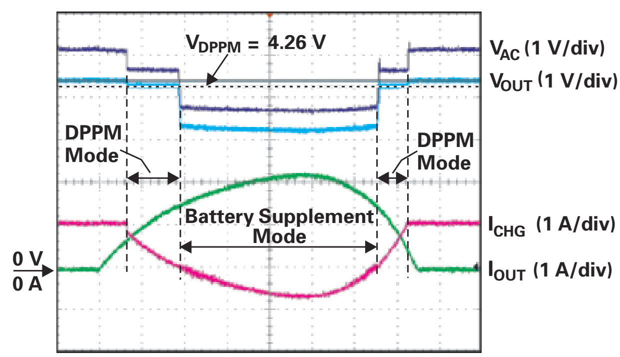

Figure 3. DPPM experimental waveforms

Conclusion

DPPM reduces the battery-charging current while powering the system load when the system bus voltage drops to a predetermined threshold due to limited input current. DPPM also completely eliminates the issues of battery and system interaction such as false charge termination and false safety-timer warnings. The DPPM battery charger is ideal for power systems that simultaneously charge the battery.

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3. bq24060 Datasheet

Figure 5 Vertical-axis Darrieus wind turbines can operate at higher efficiencies than their horizontal-axis peers; a simpler construction and immunity from wind-direction shifts are other advantages.

Jean Marie Darrieus, who patented his version in 1931, and Russian-born US mechanical engineer Alexander Gorlov, whose design won the Thomas A Edison Patent Award from the American Society of Mechanical Engineers in 2001. Quoting Wikipedia, "Albert Betz, a German physicist, determined in 1919 that a wind turbine can extract at most 59% of the energy that would otherwise flow through the turbine's cross section. The Betz limit applies regardless of the design of the turbine. More recent work by Gorlov shows a theoretical limit of about 30% for propeller-type turbines.

"Actual efficiencies range from 10 to 20% for propeller-type turbines and are as high as 35% for 3-D vertical-axis turbines, such as Darrieus or Gorlov turbines." Darrieus turbines tend to be simpler to build, because the gearbox and other subsystems are at the base of the turbine, not crammed into a nacelle on top of a tower. They also don't need to point directly into—or away from—the wind. Unfortunately, Darrieus turbines aren't universal panaceas; they have their downsides, too. Variable-direction wind-induced high stress on the vertical axis decreases reliability. Also, their low starting torque necessitates the inclusion of a supplemental rotor or separate power source to start them turning. And, because they generally reside on towers, they're constrained by the slower, more turbulent, and less efficient airflow near the ground.

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Design innovation continues for both horizontal- and vertical-axis turbines. Department of Energy documentation on turbine design, for example, points out that "the gearbox is a costly (and heavy) part of the wind turbine, and engineers are exploring direct-drive generators that operate at lower rotational speeds and don't need gearboxes" (**Reference 9**). Wikipedia notes, "Newer wind turbines often turn at whatever speed generates electricity most efficiently. The variable-frequency current is then converted to dc and then back to ac, matching the line frequency and voltage. Although the two conversions require costly equipment and cause power loss, the turbine

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can capture a significantly larger fraction of the wind energy."

The IEEE Power Engineering Society devoted its November/December 2005 issue to the subject of wind power. Smith's editorial, which introduced a five-article series, made the following comments about wind-farm-fed power-plant design: "Wind plants have benefited from steady advances in technology that have been made over the past 15 years. Much of the advance has been made in the components dealing with the utility interface, the electrical machine, the power electronic converter, and the control capability. We have come a long way from the days of the simple induction generator with soft start. We can now control the real and reactive power output of the machine within some design range subject to fuel availability, limit the positive ramp rate of the machine, control voltage, limit power output, and design for low-voltage ride-through. Soon, we will be able to provide governor functions and controlled ramp-down during high wind speed events" (**Reference 10**).

MANAGING IMPERMANENCE

Perhaps the biggest challenge—and opportunity—to those evaluating the implementation of wind turbines and equipment running on energy from those turbines is wind's inherent unpredictability. This randomness, Wikipedia explains, results from the fundamental fact that the sun provides heat unevenly to the earth; hence, the poles receive less energy from the sun than the equator does. Also, the dry land heats up and

FOR MORE INFORMATION

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General Electric
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The Massachusetts Institute of Technology's Analysis Group for Regional Energy Alternatives at the Lab for Energy and the Environment
http://web.mit.edu/agrea/

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cools down more quickly than the seas do. "The differential heating powers a global atmospheric convection system reaching from the earth's surface to the stratosphere, which acts as a virtual ceiling," says the online reference. On average, wind tends to be stronger in winter than summer and at night than during the day. Note that this situation is the exactly opposite profile of two other green power sources: hydroelectric and solar power. The approaches often neatly counterbalance each other.

Wind's night-and-winter preference is good news if you want your wind farm to supply a community's electrical-heating needs; it's bad news if you expect wind power to feed your customers' air conditioners. Although each wind farm's output is variable over less than a one-year time frame, a multifarm grid spanning multiple geographic regions can moderate some of this inconsistency. Meteorologists can often accurately predict and account for weather patterns that might affect wind-farm output, bringing online other power sources well before the weather's manifestation. Electrical pricing can also act as an effective catalyst for consumers to change their behavior. If consumers know that electricity costs more at certain times of day and less at others and that the price varies depending on wind-farm-output patterns, they might, for example, do laundry or charge their electrical cars overnight versus in the middle of the day. And, adopting a more long-term perspective, a given wind farm's year-to-year output variation is usually no more than a few percentage points up or down. Ironically, global-warming trends are most likely to affect that variation.

To flatten out some of the turbine-to-turbine output variability that occurs within a farm throughout the day, as well as to extract the maximum energy from a plot of land, a plant designer might be tempted to cram as many turbines as possible into the available space. The more-turbines-are-better strategy works, but only up to a point. Just as blade-to-blade turbulence can decrease intraturbine efficiency, placing turbines too closely together decreases interturbine turbulence efficiency, thus decreasing the entire farm's performance. Wikipedia notes that ideally "turbines are spaced three to five rotor diameters apart perpendicular to

the prevailing wind and five to 10 rotor diameters apart in the direction of the prevailing wind to minimize efficiency loss." In these optimum configurations, "the wind park effect loss can be as low as 2% of the combined nameplate rating of the turbines."

On wind compared with traditional fuel sources that utility companies can quickly bring online whenever demand warrants, Smith comments, "A wind plant is generally an energy resource, not a capacity resource. We live in a capacity world, and we have to think about a wind plant differently. It supplies cheap energy when it is available, and it is a valuable contribution to a well-designed system. A number of investigators have pointed out that a wind plant should be viewed [in] an unconventional way, as load (negative load, that is, and not generation). An examination of the statistics of wind production shows that it behaves much more like load than generation. Instead of talking about firming up the wind to make it look like something that it is not, accept it for what it is and deal with the net load accordingly. We're used to dealing with the aggregate load, which has a large degree of random behavior and uncertainty, so let's begin to think about dealing with this new net load in the same way. We don't try to balance each load on the system, so let's not try to balance each wind generator on the system. It is the net system load that's important."

The US space program, which federal budget resources primarily finance, is a tangible example of how significantly a strong government backing can advance a technology's capabilities, decrease its costs, and spur ancillary technologies. The US-government-sponsored rural-electrification program of the 1950s, which connected most US homes and businesses to a central power grid and, in doing so, ironically closed the book on the windmill's role as a power provider for farms, showed how strong government backing can radically transform a culture. Wind power, along with other renewable resources, will benefit from similar strong government backing, as the downsides of a fossil-fuel-dependent culture become increasingly evident.

Ironically, Smith also mentions the US space program in a call to arms that closes his wind-power treatise. "The electric-power system is the most complex machine ever devised, more complex even than the manned space-flight program. The design and operation of such a machine could only be carried out by an incredibly talented, capable, intelligent group of people. That group is the long list of scientists, engineers, technicians, mathematicians, computer scientists, and other people who have dedicated their lives to the development, care, and feeding of this machine. I submit that this group is still the most creative, talented, intelligent, and dedicated group of professionals in the world. We have been faced with challenges and problems throughout the history of our industry, and we have always risen to the occasion, solved the problems, and moved on. I have every reason to believe that we will continue to do the same." **EDN**

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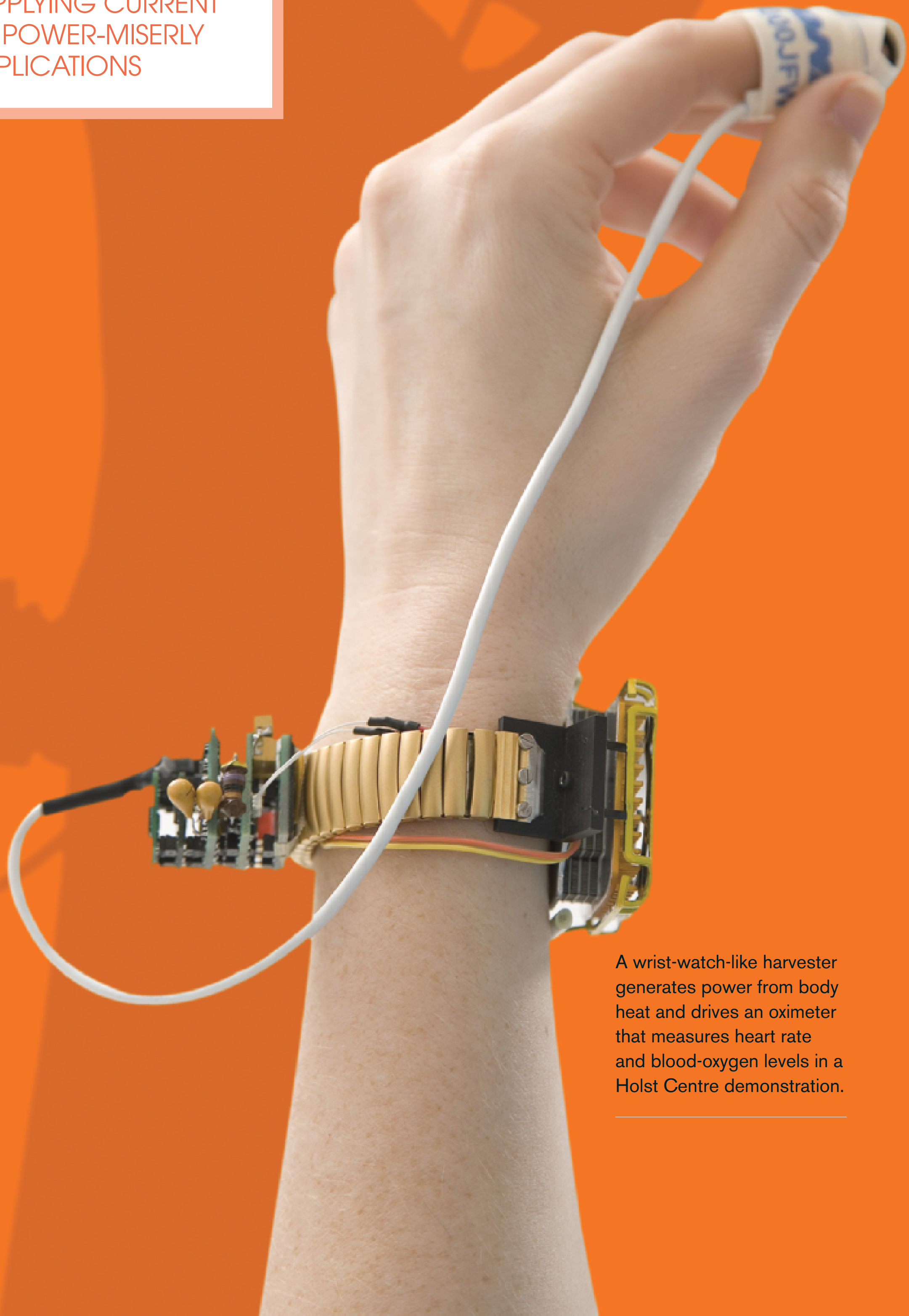


A wrist-watch-like harvester generates power from body heat and drives an oximeter that measures heart rate and blood-oxygen levels in a Holst Centre demonstration.

BY MAURY WRIGHT • EDITOR IN CHIEF

HARVESTERS GATHER ENERGY FROM THE ETHER, POWER LIGHTWEIGHT SYSTEMS

There's no free lunch, right? Your mom and dad probably told you as much. So surely we can't extract energy from thin air. Or can we? Actually, the human body, factory machines, radios of various types, and many other things emit energy in the form of heat, vibration, or RF waves. And it's looking increasingly plausible that designers can devise systems that scavenge the stray energy and convert it for use in powering systems—albeit very low-power ones. You won't soon see a mobile handset powered from the ether, but potential realistic applications include portable medical monitors and even home-automation devices.

Energy harvesting or scavenging is more about enabling compelling new applications than about saving money on power. Tech-industry visionaries have for some time been speaking of an era of ubiquitous processors embedded into the fabric of our lives. Borrowing a passage from our 50th anniversary issue (www.edn.com/50th), Texas Instruments Principal Fellow Gene Frantz said, "You can almost say that we are on the path to the vanishing product—where the product will be so small and insignificant in size, but so significant in capability, that we really don't know where we have it; we just know we have it." It's easy to imagine many such microprocessor-based devices both on our persons and in places such as a smart light switch or thermostat.

Arguably, microcontrollers have already pervaded our lives. Microchip Chief Executive Officer Steve Sanghi states, "You get up, and the first thing you interface with is an alarm clock, then maybe an electric shaver, a hair dryer, a blender, a refrigerator. … By the time you have left your home, you have used a large number of microcontrollers already. Then you get into your car, and there are 40 to 50 microcontrollers adding to your safety, comfort, convenience, and entertainment." Sanghi points out that microcontrollers monitor highway traffic and that, at work, we face another avalanche of the devices.

Today, an ac source or batteries can conveniently power all of these applications. The next step, however, in which processors are embedded in textiles, in walls, on bridges, and everywhere, will require either a replacement for the battery or at least a symbiotic technology that can charge a battery from the ether, greatly extend the usable life of a battery, or do both. The answer may be the energy harvesters that this article discusses or perhaps new types of miniature fueled generators (see **sidebar** "Is that an engine on your chip?" in the Web version of this article at www.edn.com/061215df2).

As TI's Frantz is quick to point out, harvesting energy isn't new. Solar energy is an example that has been around for years. Franz points out the long history of solar-powered watches and calculators at TI. Those products use a battery that's augmented with solar panels that recharge the battery. Seiko also briefly sold a wristwatch that was powered by body heat (www.sii.co.jp/info/eg/thermic_main.html).

And there are several examples of enabling technologies that manufacturers are now shipping that designers can use in some manner to harvest energy. You can find previous coverage of the technology and some product examples in **Reference 1**. That article, for instance, covered two products from EnOcean that enable products for home- or building-automation applications.

For instance, EnOcean offers a switch that finds use mainly in lighting control, although you could also use it to control powered draperies, fans, or other devices for which you might have a wall switch in a home or office. The baseline product is the ECO 100 module, which the company refers to as an "electrodynamic" harvester. The company bases the module on a coil and a magnet that together convert linear motion into power. More specifically, the action of a person pushing the switch generates a burst of energy, because the actuator changes the flux through the coil. The company previously offered a piezoelectric harvester for the same application but claims that the new design is more efficient.

EnOcean bundles the ECO 100 into the PTM 200 switch module. The company is selling the product into lighting and other applications. When you depress the light switch, the harvester generates sufficient energy to awaken a processor and radio in the PTM 200 that then transmit three short duplicate message packets to a receiver. You could integrate the receiver into a light fixture, but you would more typically wire it between the ac power and a fixture. The wall switch requires neither wiring nor a battery. The receiver operates from ac power.

EnOcean Vice President of Sales and Marketing Jim O'Callaghan claims that, unlike most other attempts at lighting control, the harvester approach makes economic sense despite a switch design that's far more complex than the typical wall switch, which directly switches the ac power. O'Callaghan claims that the money you save by not running ac wiring to switches will pay for the higher cost of the switch and the receiver that's integrated in the fixture.

According to O'Callaghan, the PTM 200 sells for $10 to $20, depending on volume, and the finished light switch goes for around $50 (one). You can buy the switches for home use from companies such as Ad Hoc Electronics (www.adhocelectronics.com). Ad Hoc's Web site prices the combination of a switch and a receiver module that integrates a relay to switch ac power at about $120 in small quantities. O'Callaghan claims that EnOcean has sold as many as 3000 to 4000 switches into single commercial installations.

Technically, you could argue that the switch product from EnOcean isn't a true harvester, because it doesn't gather stray energy. But it does accomplish the mission of something from nothing. The company has also developed solar and thermal products. **Reference 1** discusses in detail the solar product, which has found use in thermostats inside buildings. The product can harvest incandescent and fluorescent light sources and has two types of energy storage that allow for operation even when the lights are off for extended periods.

Manufacturers of thermal harvesters take advantage of the Seebeck Effect—the ability of a thermocouple to generate power based on the temperature differential between hot and cold plates. EnOcean demonstrated its thermal harvester at last month's Electronica trade show in Munich, Germany. The demonstrations were relatively simple. In one demo, a person placing a finger on a plate would generate the temperature differential needed to awaken the processor, which would then transmit a temperature reading to a receiver con-

AT A GLANCE

- Heat, vibrations, and RF are all potential sources that harvesters can convert into microwatt-power levels.
- Harvesters typically store energy for sporadic use, and designs must couple them to low-power systems that can operate sporadically.
- Designs typically couple energy-harvesting advancements with applications that can take advantage of a sporadic low-power source.

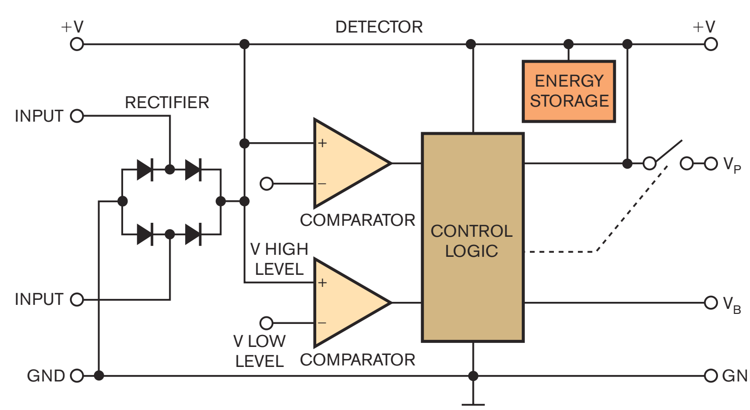


Figure 1 Most harvesting applications rely on electronics that sporadically come to life, but a monitoring subsystem, such as this one, must continuously operate at ultralow-power levels, monitoring the energy store and awakening the processor to the task at hand when sufficient power is available.

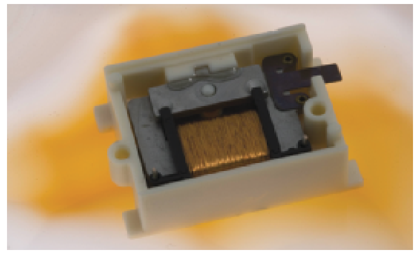
nected to a notebook PC. The second demonstration relied on the difference between the air temperature and the temperature of liquid in a glass to generate power.

The EnOcean thermal harvester, however, is a good example of some of the obstacles in the energy-harvesting market. EnOcean is in the business of designing enabling technologies. It is seeking partners that have ideas for compelling end applications to drive the technology to market. For now, the thermal harvester is awaiting such partners.

Of course, more efficient and lower cost harvesting technology is perhaps the biggest roadblock to broad deployment. A number of universities and R&D organizations are attacking the problem from various directions. The Holst Centre in Eindhoven, the Netherlands, is perhaps moving the fastest on energy-harvesting technology. The research giant IMEC (Interuniversity Microelectronics Center, Leuven, Belgium) together with the Dutch research institute TNO (The Netherlands Organization) established the Holst Centre in 2005. The Wireless Autonomous Transducer Solutions initiative at Holst is a major program that includes energy harvesting. The Holst Centre is working on thermal, vibration, and RF approaches.

Given IMEC's deep involvement in semiconductor and MEMS (microelectical-mechanical-systems) technologies, it's not surprising that the energy-harvesting work seeks to take advantage of those strengths. In the thermal area, the researchers at Holst have focused on a MEMS-based thermopile approach to creating a TEG (thermo-electric generator). A thermopile is essentially an array of thermocouple elements. Electrically, the elements connect in series so that the thermopile sums the voltage that each element produces. The elements connect in parallel, thermally tying together cold or reference junctions and connecting the opposing hot junctions. The greater the difference in temperature across the thermopile, the more current it generates.

As you might expect, commercially available thermopiles are too expensive to meet the needs of a scavenging application that would require many elements in series to generate a usable voltage. But Holst officials believe that the institute can use a MEMS approach to build an acceptable array. Even with the MEMS approach, the miniature dimensions of semiconductors introduce problems, as well. The minute height of the thermocouples essentially allows parasitic plate-to-plate thermal conductance. The Holst researchers hope to address that problem by building the thermocouple array on a silicon rim that both increases the space and provides an isolating air gap between the plates.



The force generated by a person pushing a switch creates the linear motion necessary for a coil and a magnet to generate a power pulse. This pulse can briefly power a processor and radio in EnOcean's wall switch.

The Holst researchers have been working on a prototype application while developing the MEMS TEG. The prototype is an oximeter—a medical device that measures heart rate and the amount of oxygen in the blood. The prototype relies on a commercial fingertip sensor that similar medical applications use. It couples to an electronic subsystem that operates at low power.

Holst has yet to manufacture a workable monolithic TEG. The prototype uses discrete thermopiles manufactured in BiTe (bismuth telluride) with a total of 5000 thermocouple elements measuring 5 to 6 cm^2 in area. The thermopiles mount onto what looks like a wrist watch, placing the reference thermal plate against the skin. Human-skin temperature is typically 33°C. The Holst researchers position the watchlike TEG on the inside of the wrist on the radial artery to maximize the temperature.

In an environment with an ambient temperature of 22°C, the prototype TEG can deliver 100 μW of power. The oximeter design can take a measurement and wirelessly transmit that measurement once every 15 sec while consuming 62 μW of power.

The first step in developing the monolithic TEG is an SiGe (silicon-germanium) device to prove the concept, although the models that the researchers have developed make it clear that SiGe won't deliver anything near the 100 μW of the prototype. They hope to achieve 5 μW with the SiGe TEG implementation. At that power level, you could still run the oximeter, albeit at a much lower duty cycle. Program Director Bert Gyselinckx suggests that the system might take a few measurements per hour rather than four per minute. It's also worth noting that the Hoslt harvester would be a significant advancement over Seiko's thermoelectric watch, which ran from a 1-μW harvester.

Assuming that the SiGe TEG works as planned, the team will then build a monolithic MEMS-based TEG in BiTe. According to Gyselinckx, models show that such a design could deliver 30 μW. Both of the planned monolithic designs will yield a 1-cm^2 die, which is the footprint of the TEG. Although a BiTe TEG isn't theoretically more difficult to fabricate than an SiGe TEG, the SiGe device is manufacturable on many CMOS fab lines, whereas the BiTe device is not. And, although the entire TEG effort shows great promise, a mass-market TEG is surely several years away.

Meanwhile, the Holst researchers are pursuing several other applications and types of harvesters. Gyselinckx believes there will be other medical applications in hearing aids and perhaps even in medical devices that you implant in the body. "There are some thermal gradients inside the body," he says.

Gyselinckx also points out potential applications in industrial and factory settings. A designer looking to deploy a thermal harvester in a factory would likely find usable thermal gradients. But why use a harvester where power is plentiful? Gyselinckx claims that it is simpler to add monitoring networks with no new wires for power or data, which leads to the combination of harvesters and wireless networks.

As for other harvesting technologies, Holst is pursuing both piezoelectric- and electrostatic-based vibration harvesters. In both instances, the researchers are focusing on semiconductor-manufacturing techniques to implement the harvesters. In an electrostatic approach, the researchers hope to use MEMS technology and multiple wafers. One wafer will move with respect to the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bottom fixed one in the face of vibration and, in doing so, vary capacitance to generate current to a load.

You will also find vibration-based harvesting technology from Perpetuum. **Reference 1** covers the basics, and, more recently, *EDN* covered the company's newest generator (**Reference 2**).

Of course, the researchers at Holst, EnOcean, and other companies also face the problem of low-power circuits and power-miserly wireless-network technologies. That's one reason that Holst built an end application. Check the Holst Web site for details on the dc/dc-converter design and other specifics of the oximeter.

Likewise, much of EnOcean's work is on the system-level details, such as the wireless network. The company chose to locate its wireless network in the 868.3-MHz band, in which it can do short data bursts using amplitude modulation and do so in compliance with regulatory agencies worldwide. The company claims that, with 50 μW of power, the technology can transmit a signal over a range of 300m.

The need for ultralow-power ICs and components is yet another problem that designers will face in harvesting applications. ALD (Advanced Linear Devices) has for years tended a niche market in very-low-power MOSFETs and now hopes to use that expertise in harvesting applications. The company first announced what it calls zero-threshold MOSFETs, which operate with a gate threshold as low as 200 mV. Later, the company introduced programmable arrays of such MOSFETs and now plans a series of modules for energy harvesting that leverage the low-power MOSFETs.

According to ALD Chief Executive Officer Bob Chao, much of the secret to getting harvesters to work in real applications is in monitoring the stored energy and controlling just when the processor and other circuitry can awaken and perform the task at hand. The simple schematic in **Figure 1** indicates Chao's point. You must have some circuit that operates continuously to monitor the harvester store, and that's where ALD's technology comes into play.

Chao claims that ALD will introduce three modules in early 2007 for use in vibration applications. What he is calling Model A for now will be a 4.5-mJ device that can deliver 25 mA at 1.8V.

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The device will sporadically deliver this load—perhaps once every few hours, depending on the vibration environment. The power capacity will be suitable to temporarily power a Zigbee application. The other modules will offer even greater power but perhaps with less frequent operating capacity. Chao claims that the modules will be the size of AA batteries.

Chao also claims that ALD has deployed its technology in a series of vibration-powered sensors on an automotive bridge. The passing autos create the vibration. But Chao can't name the installation for now, because ALD simply supplied the enabling technology to the contractor.

Although much of the energy-harvesting technology is in the prototype stage today, it's clear that some real application will emerge in the ensuing years. Other players include Thermo Life, which is working on thermal harvesters. Both MicroStrain and Ferro Solutions are working on vibration-based harvesters for military applications. The challenge to designers will be to match a harvesting technology to a compelling application. EDN

REFERENCE

1 Conner, Margery, "Energy harvesters extract power from light, vibrations," *EDN*, Oct 27, 2005, pg 45, www.edn.com/article/CA6275407.

2 Prophet, Graham, "Vibration powers wireless sensors," *EDN*, Sept 1, 2006, pg 26, www.edn.com/article/CA6363917.

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DESIGN NOTES

Versatile Current Source Safely and Quickly Charges Everything from Large Capacitors to Batteries – Design Note 405

David Ng

Introduction

The LT®3750 is a current mode flyback controller optimized to easily and efficiently provide a controlled current to charge just about any capacitive energy storage device. The LT3750's simple but flexible feature set allows it to handle a wide variety of charging needs. These include large high voltage capacitors for professional photoflash equipment and emergency beacons, small capacitors that are charged and discharged thousands of times a second, and batteries for long term energy needs.

Safe, Small and Flexible

All of the control and feedback functions of the LT3750 are referred to the charger's input. The target voltage is set by just two resistors in a simple, low voltage network that monitors the flyback voltage of the transformer. When charging a capacitor to a high voltage, there is no need to connect any components to the hazardously high output potential. The charging current is a triangle wave whose amplitude is set by an external sense resistor and the flyback transformer turns ratio.

The LT3750 operates in boundary mode, at the edge of continuous and discontinuous conduction, which significantly reduces switching losses. This in turn allows for high frequency operation, and a correspondingly small flyback transformer size. The LT3750 is itself tiny, available in a 10-lead MSOP package.

The LT3750 is also compatible with a wide range of control circuitry. It is equipped with a simple interface consisting of a CHARGE command input bit and an open-drain $\overline{\text{DONE}}$ status flag. Both of these signals are compatible with most digital systems, yet tolerate voltages as high as 24V. The LT3750 operates from 3V to 24V DC.

Simple Strobe Capacitor Charger

Figure 1 shows a LT3750 circuit that charges a 400µF strobe capacitor to 300V. This capacitor and voltage combination is typical of professional photoflash systems, security devices and automotive light strobes. The target voltage is set by the two resistors R2 and

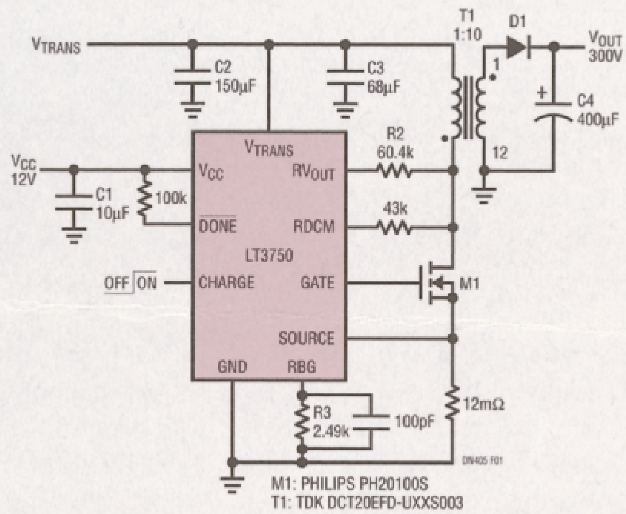

Figure 1. LT3750 Circuit Charges 400µF Capacitor to 300V. DANGER HIGH VOLTAGE—OPERATION BY HIGH VOLTAGE TRAINED PERSONNEL ONLY

R3, which together monitor the MOSFET drain voltage. This voltage, when referenced to the input rail, is directly proportional to the output potential while power is being transferred to the output capacitor. The LT3750 compares this to an internal reference and terminates the charge cycle when the output has reached the desired target voltage, after which the LT3750 sets the $\overline{\text{DONE}}$ bit to signal the system microcontroller that the charge cycle is complete.

As shown in Figure 2, the LT3750 charges the 400µF to 300V in about 0.92 seconds when the circuit is powered from a 12V source. Note that the output current amplitude is constant throughout the charge cycle.

Charge Small Capacitors Fast

Many devices need to provide energy to a transducer multiple times per second, such as diagnostic equipment and device testers. Figure 3 shows that, for the same circuit

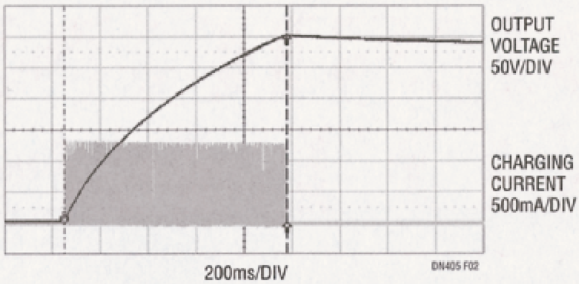

Figure 2. LT3750 Charges 400µF to 300V in 0.92 Seconds

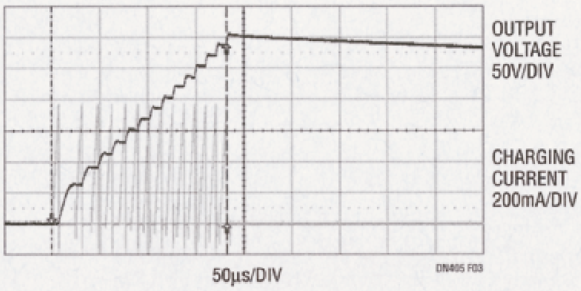

Figure 3. LT3750 Charges 0.1µF to 300V in 180µs

as in Figure 1, the LT3750 is capable of charging a 0.1µF capacitor to 300V in just 180µs. The only change in the circuit is the replacement of the 400µF output cap with one that is much smaller. The performance of the circuit is essentially the same, other than the charge time. As far as the output device is concerned, the LT3750 circuit is a current source.

Charge Batteries Too

Another type of system that needs a controlled current source is a fast charger for a lead-acid battery. A fast charger for a lead-acid battery differs from the capacitor charging applications in that it needs to charge at high current, but at a much lower voltage. Figure 4 shows a circuit that charges at 6A until the lead-acid battery potential reaches the 14V float voltage. Again, the circuit is remarkably similar to the previous two designs—the transformer turns ratio is now 1:1 and the R2 set resistor has been changed to set the target float voltage to 14V. Other float voltages may be accommodated by simply changing R2 to the appropriate value.

When the battery voltage reaches 14V, the LT3750 sets the $\overline{\text{DONE}}$ bit. This can then be used to signal the system microcontroller, which can then enter a "trickle-charge" mode by setting the CHARGE bit at a fixed, low frequency interval.

Conclusion

The LT3750 is an easy-to-use controller that is ideal for applications where there is a need to charge an energy storage device to a predetermined target voltage. Its unique architecture allows it to be used in just about any application where a controlled current source is needed, with almost no limitation on the output voltage.

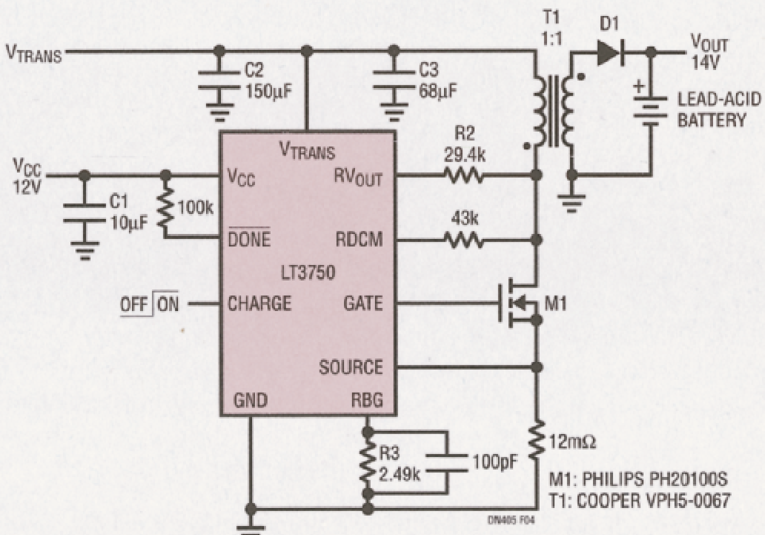

Figure 4. LT3750 Battery Charger with Microcontroller Interface for Variable Current Charging

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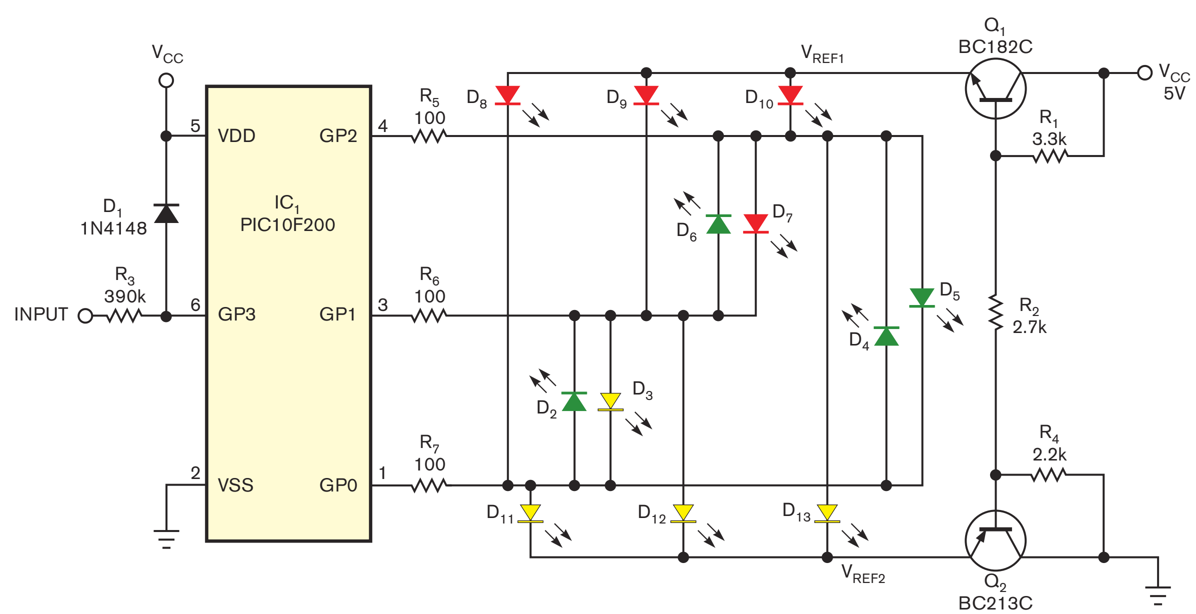
Three microcontroller ports drive 12 LEDs

Nedjeljko Lekic and Zoran Mijanovic, University of Montenegro, Department of Electrical Engineering, Podgorica, Montenegro

Based on a previously published Design Idea (**Reference 1**), the circuit in **Figure 1** uses only three I/O lines to drive 12 LEDs. In this application, the circuit serves as a tachometer for a motor-vehicle engine and displays relative engine speed on an array of LEDs arranged in a line or a circular arc. Three pairs of inverse-parallel-connected LEDs (D_2 and D_3, D_4 and D_5, and D_6 and D_7) receive drive current from IC_1's ports through current-limiting resistors R_5, R_6, and R_7. Two groups of three LEDs, D_8, D_9, and D_{10} and D_{11}, D_{12}, and D_{13}) connect among IC_1's ports and two voltage dividers that supply reference voltages V_{REF1} and V_{REF2}. Varying the values of resistors R_5, R_6, and R_7 adjusts the brightness of the middle six LEDs, and R_1, R_2, and R_4 control the brightness of the outer six LEDs. In general, this circuit can use N of a host microprocessor's I/O lines to drive as many as N(N−1)+2N LEDs, or 2N more LEDs than the circuit in the original Design Idea could drive.

DIs Inside

The circuit uses Microchip's (www.microchip.com) PIC10F200 microcontroller, IC_1, a small, inexpensive, six-pin device that provides only three I/O pins and one input-only pin. The I/O pins—GP0, GP1, and GP2—drive a 12-LED bar graph comprising



NOTE: LEDs ARE PANASONIC SSG LN224 SERIES (RED), LN324 SERIES (GREEN), AND LN424 SERIES (YELLOW).

Figure 1 A PIC microprocessor and a 12-LED bar-graph display form a simple tachometer circuit. (The decoupling capacitors are not shown.)

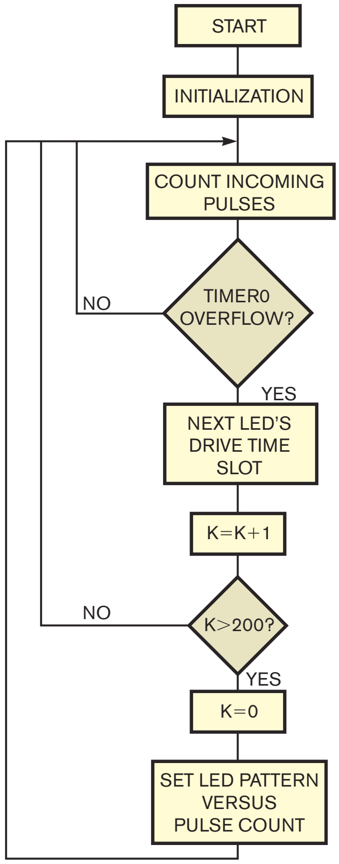


Figure 3. This flow chart shows the LED-driver software routine. (See the listings at www.edn.com/061215di1 for the complete tachometer routine.)

Figure 2. The bar graph display's 12 LEDs can form a linear array or circular arc (not shown).

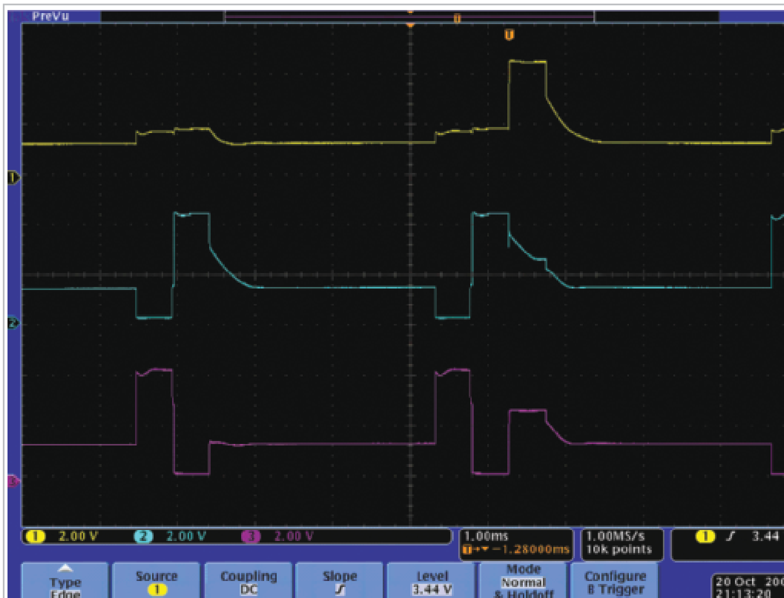


Figure 4 A digital oscilloscope captures the waveforms of GP0, GP1, and GP2 (upper to lower traces, respectively), which show a transition in the LED pattern from Case 7 to Case 8 (lines 62 and 63 in Listing led121.c.pdf).

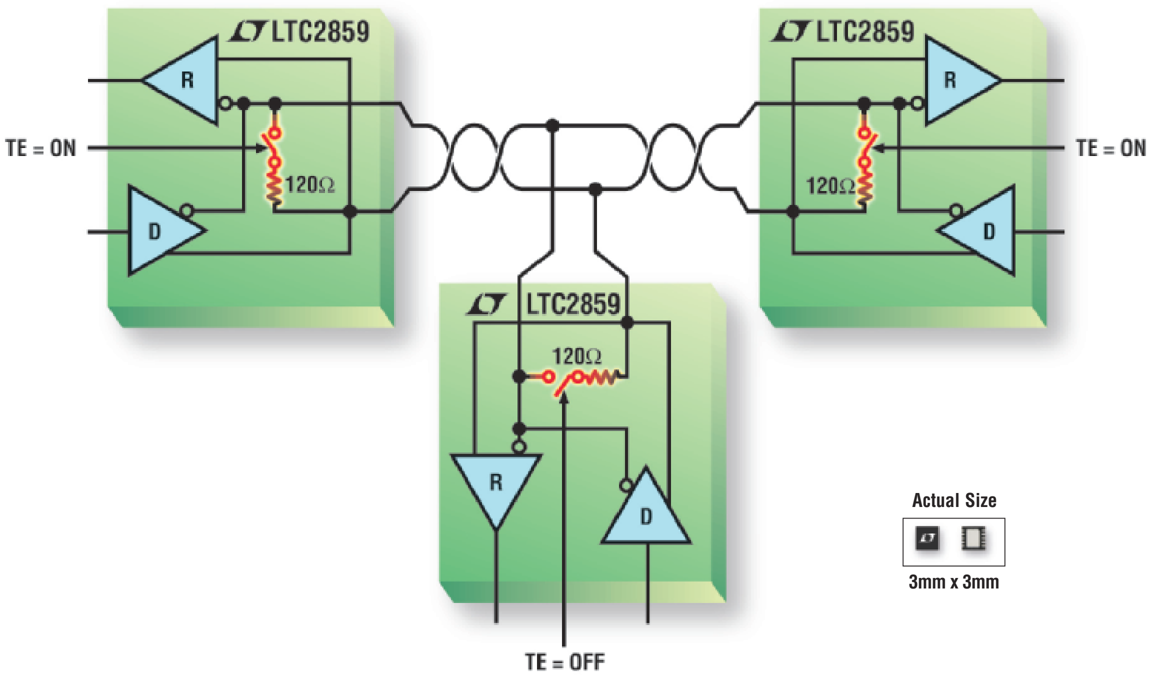
four yellow LEDs, four green LEDs, and four red LEDs driven in multiplexed mode (**Figure 2**).

The microprocessor's input-only pin, GP3, serves as the input for pulses coupled from the ignition coil's primary terminal. Resistor R_3 and diode D_1 provide input-signal conditioning, and a software-debouncing routine removes ringing effects from the pulses. Given R_3's high value of 390 kΩ, the circuit tolerates high-voltage input spikes and prevents latch-up of the PIC10F200. Port GP3, which serves as the processor's programming port, differs from the processor's other ports because it incorporates an internal protection diode. The 20-mA diode prevents GP3 from negative-going transient voltages. The circuit operates reliably, but you can add an external protection diode for enhanced protection against transient-induced latch-up. Connect the diode's anode to ground and its cathode to pin GP3 of IC_1.

You can configure the bar graph to indicate engine speed by the number of LEDs turned on (bar mode) or by illuminating only one or two LEDs (dot mode). The color scheme in **Figure 2** uses yellow LEDs to indicate too-low speed, green LEDs for nominal speed, and red LEDs for excessive speed. **Figure 3** shows the indicator software's flow chart. The processor's internal clock drives Timer0 to overflow every 512 μsec, which represents one time slot—that is, a multiplexing phase. Of eight time slots, one drives the three upper LEDs, and a second drives the three lower LEDs. For software simplicity, the last six time slots drive the middle LEDs one by one. At the start of the main loop, the microprocessor counts clock pulses and waits for Timer0 to overflow. After overflow occurs, the output ports drive the LEDs according to their assigned time slots. After eight time slots elapse, the processor sets the ports to the same state. After 200 time slots, the processor counts incoming tachometer pulses and sets the LED pattern according to the incoming pulse count—that is, according to input frequency.

The tachometer indicates rotary speed as high as 120 cycles/sec. The accompanying software listings available at www.edn.com/061215di1 include files in C language (led12.c.pdf) and in assembly language (led12.asm.pdf). The source zip file contains a complete MPLab project. **Figure 4** shows the waveforms, which a digital oscilloscope captured at ports GP0, GP1, and GP2. EDN

RS485 with Switchable Termination



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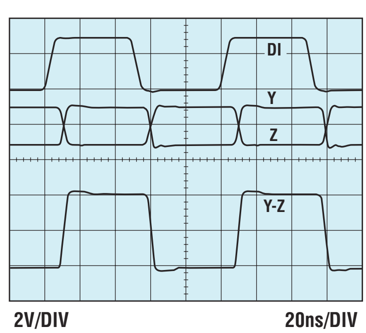

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Magnetic-field probe requires few components

Rama Sarma, EMI-EMC Centre, RCI, Hyderabad, India

Popularly known as "gauss meters," various makes and models of magnetic field meters are available on the market at prices that make them unaffordable to many hobbyists and engineers. This Design Idea combines a commonly available DMM (digital multimeter) with a single semiconductor component to measure magnetic-flux density and, in turn, magnetic-field intensity.

Figure 1 illustrates the measurement equipment, comprising a probe, its battery pack, and a DMM. The probe's active element consists of a linear Hall-effect sensor. Although virtually any linear Hall sensor will work in this application, this version of the probe uses an Allegro MicroSystems Inc (www.allegromicro.com) A1323 sensor, which produces a voltage proportional to an applied magnetic field (**Reference 1**). Operating from a power supply of 4.5 to 5.5V, the A1323's quiescent output voltage (zero-field output) rests at 50% of the supply voltage. Given its nominal sensitivity of 2.5 mV/gauss, the A1323 provides a full-scale range of 1800 gauss (4.5V/2.5 mV/gauss=1800 gauss) for a supply voltage of 4.5V.

Applying a magnetic field oriented south of the sensor's face increases the sensor's output voltage in proportion to the applied field perpendicular to the sensor's branded face, and applying a magnetic field north of the same face causes a proportional decrease in output voltage. For a supply of 4.5V, the sensor's quiescent output voltage of 2.25V can increase to 4.5V for a 900-gauss, due-south field or decrease to 0V for a 900-gauss, due-north field. Although the sensor can detect the intensity and polarity of a dc magnetic field, its ac-field bandwidth extends to 30 kHz.

The probe's breadboard version comprises a small piece of pc board of sufficient length to fit the operator's hand (**Figure 2**). The sensor's leads connect to a length of high-quality, three-conductor shielded cable and two 10-nF surface-mounted decoupling capacitors. The sensor's power supply comprises three series-connected, miniature, 1.5V batteries for a total of 4.5V. For a larger full-scale-measurement range, use a 9V battery to feed a 5V regulator IC, such as a 7805 voltmeter and add an on/off switch if desired. Place the batteries near the meter. Otherwise, the batteries' steel cases will disturb the magnetic field under observation. Use 10-nF SMD capacitors to decouple the sensor's input and output pins. Although any DMM offering high dc accuracy and an ac bandwidth exceeding 50 kHz can display the sensor's output, a DMM with a RELΔ ("relative-difference-from-reference-reading") function, such as a Fluke (www.fluke.com) model 187 DMM, eases measurement

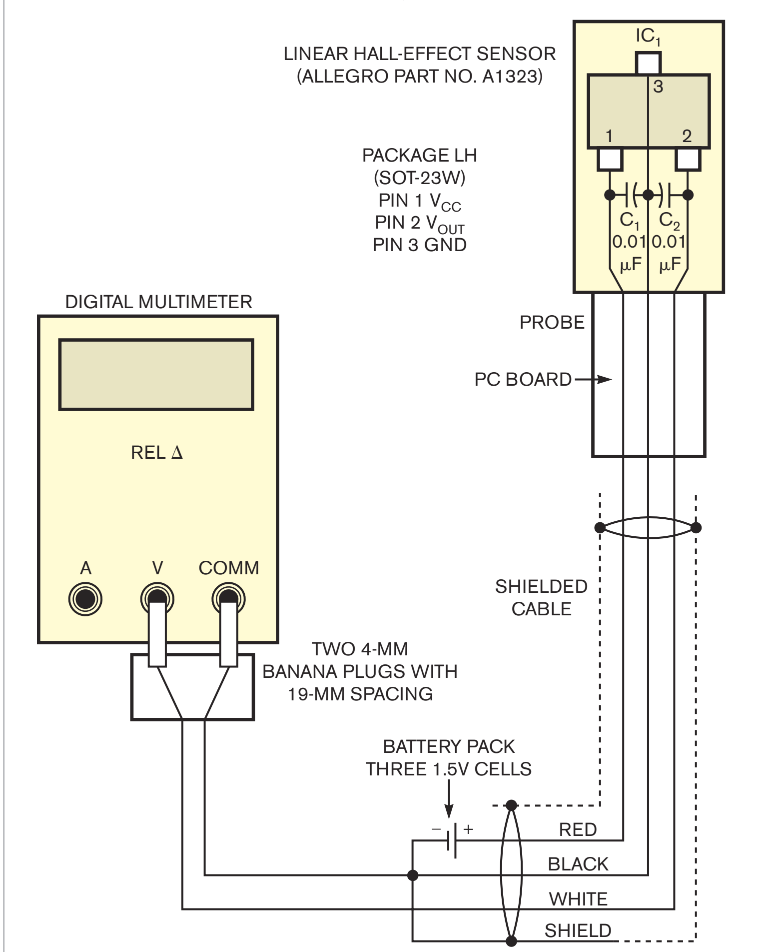

Figure 1 A digital multimeter and a Hall-effect sensor form an easily assembled magnetic-field probe.

GPON ONT REFERENCE DESIGN LOWERS COST AND SHORTENS DEVELOPMENT TIME

Maxim's complete chipset simplifies the design and lowers the cost for GPON ONTs. The chipset includes a burst-mode laser driver, either the industry-leading MAX3656 with integrated APC or the MAX3643 which is more flexible, programmable, and lower in cost. The MAX3745 TIA and the MAX3747A limiting amp provide the required receiver sensitivity. The low-power MAX3654 is the first integrated 5V video amplifier optimized for this application.

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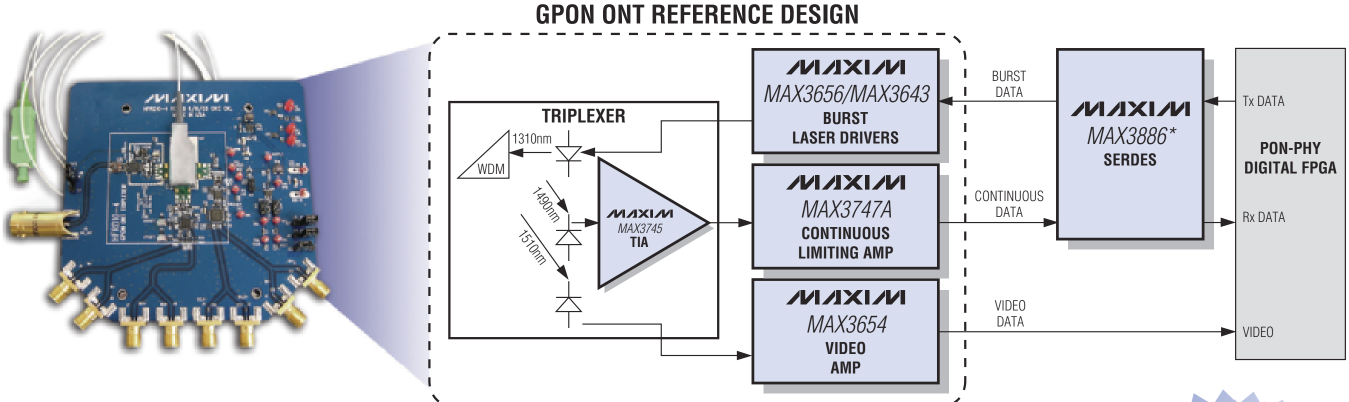
GPON ONT REFERENCE DESIGN



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MAX3654	Low-cost, integrated video amplifier	•Single +5V supply operation •47MHz to 870MHz operation •Small 4mm x 4mm QFN package •Integrated +4dB gain tilt
MAX3886*	Low-cost GPON ONT SERDES with 622Mbps/311Mbps LVDS I/O	•4-bit, 2.488G/1.244G SERDES with CDR •Compatible with low-cost FPGAs •Integrated reference oscillator
MAX3747A	155Mbps to 3.2Gbps limting amplifier	•< 2mV$_{P-P}$ input sensitivity •> 57dB gain •LOS with programmable threshold
MAX3745	2.488Gbps TIA	•10ps$_{P-P}$ DJ for < 100mA inputs •330nA$_{RMS}$ input referred noise •2GHz small-signal bandwidth

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and polarity detection of a dc magnetic field (**Reference 2**).

After assembling the circuit, connect the probe's output to the DMM using two 4-mm banana plugs. Allow a one-minute warm-up and place the probe's sensor in a magnetically shielded enclosure. (Editor's note: You can use salvaged steel, or "tin," concentrically fitting food cans to build a magnetically shielded enclosure. Arrange the cans so that their unopened ends point in opposite directions. Drill a small opening in the larger can's unopened end to accommodate the sensor's output cable.) Press the DMM's RELΔ function key. The DMM's display will show the sensor's quiescent voltage output of 2.25V as 0.0000V, indicating that the probe is calibrated for a zero magnetic field and ready for use.

Remove the probe from the shielded enclosure and measure the magnetic field under observation. To achieve maximum sensitivity, place the sensor's face perpendicular to the field. If the field's direction is unknown, rotate the probe about its longest axis to search for maximum voltage. To calculate the magnetic-flux density, divide the output-voltage reading by the sensitivity (2.5 mV/gauss). For example, if the meter reads −1.9800V, then the magnetic field is 792 gauss due north. For an ac-magnetic-field measurement, use the DMM's true-rms mode to read the sensor's ac output voltage.

Figure 2 The digital multimeter's relative-change mode (RELΔ) displays a near-zero magnetic field reading and the sensor's nominal zero-field output voltage of 2.25V.

You can calculate a magnetic field's intensity in air by applying the following formula: $B=\mu_0 \times H$, where B represents magnetic-flux density in teslas, H represents magnetic-field intensity in amperes per meter, and $\mu_0=4\pi\times10^{-7}$H/m (the permeability of free space). Given that the tesla represents a relatively large measurement unit, a 1T field is quite strong.

For greater measurement resolution, apply the following conversion factors to use the gauss, a more popular unit: 10,000 gauss=1T, 1 gauss=79.6 A/m, 1.2560 mT=1 kA/m. Applications for the magnetic-field sensor include troubleshooting moving-magnet linear-position detectors, fabrication of dc motors and audio speakers, investigation of low-frequency-magnetic-field interference, and designing and fabricating electromagnetic-interference shields.EDN

REFERENCES

1. A1323 Ratiometric Linear Hall-Effect Sensor Data Sheet, Allegro MicroSystems Inc, www.allegromicro.com/sf/1321.
2. *User's Manual, Model 187 & 189, True RMS Multimeter*, Fluke Corp, www.fluke.com.

Dynamic siphon steals current from USB port

Donald Schelle, Maxim Integrated Products Inc, Sunnyvale, CA

A USB port offers a handy source of 5V power for auxiliary devices. A USB port not only supplies power to a microcontroller and other essential circuitry, but also provides enough extra current head room to charge a small battery or supercapacitor energy-storage element. One typical approach to exploiting a USB port's leftover-current capability begins with an estimation of the essential circuitry's maximum current drain. You then place an appropriate current-limiting

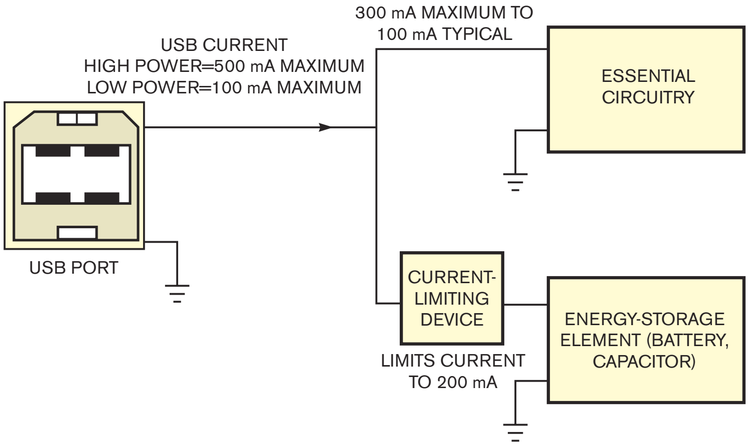

Figure 1 In this typical method for drawing power from a USB port, the storage-element current is limited to a fixed value that is less than optimal.

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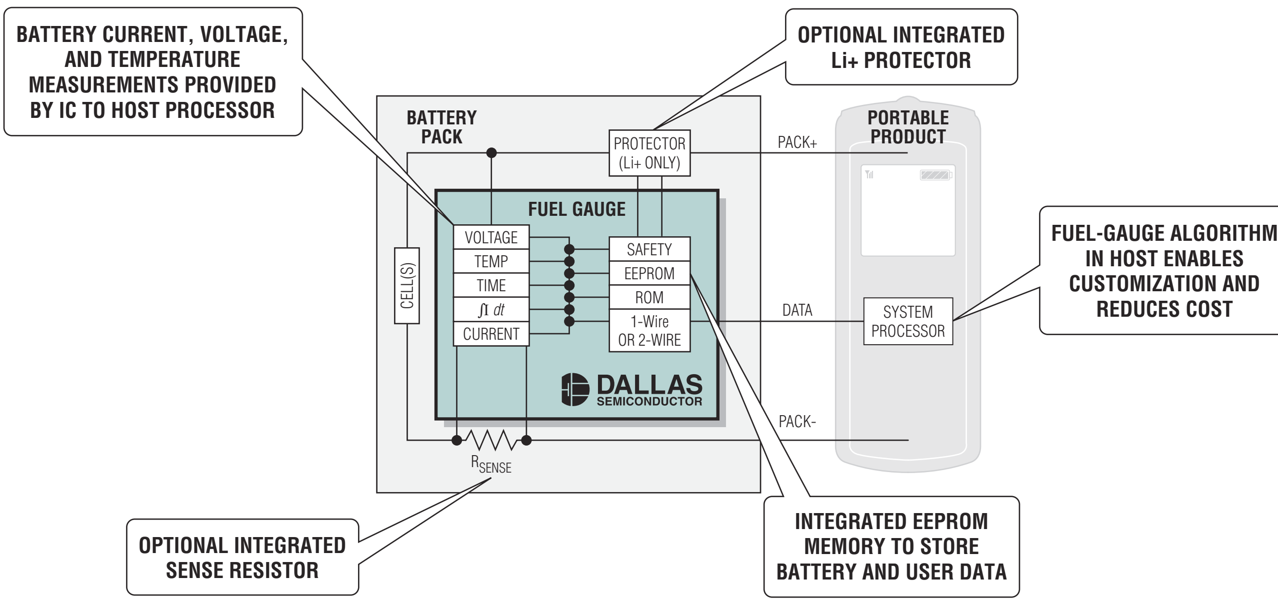

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DS2746	2-wire	14	—	11/11	—	10-TDFN (3 x 3)
DS2751	1-Wire	13	32	10/11	—	8-TSSOP (3 x 6.4)
DS2756	1-Wire	13/16	96	10/11	—	8-TSSOP (3 x 6.4)
DS2762	1-Wire	13	32	10/11	Yes	16-TSSOP (5 x 6.4), flip chip
DS2764	2-wire	13	32	10/11	Yes	16-TSSOP (5 x 6.4)

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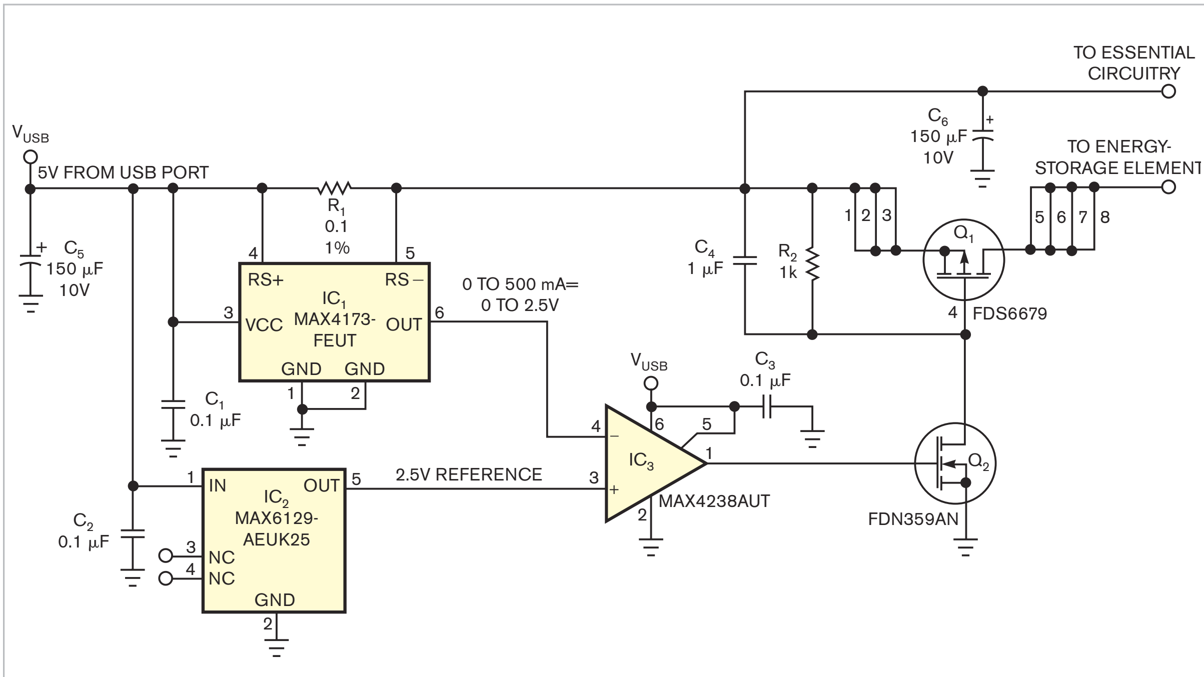

Figure 2 This circuit continuously monitors the total current drawn from the USB port and dynamically adjusts the storage-element current to avoid exceeding the port's maximum output capability.

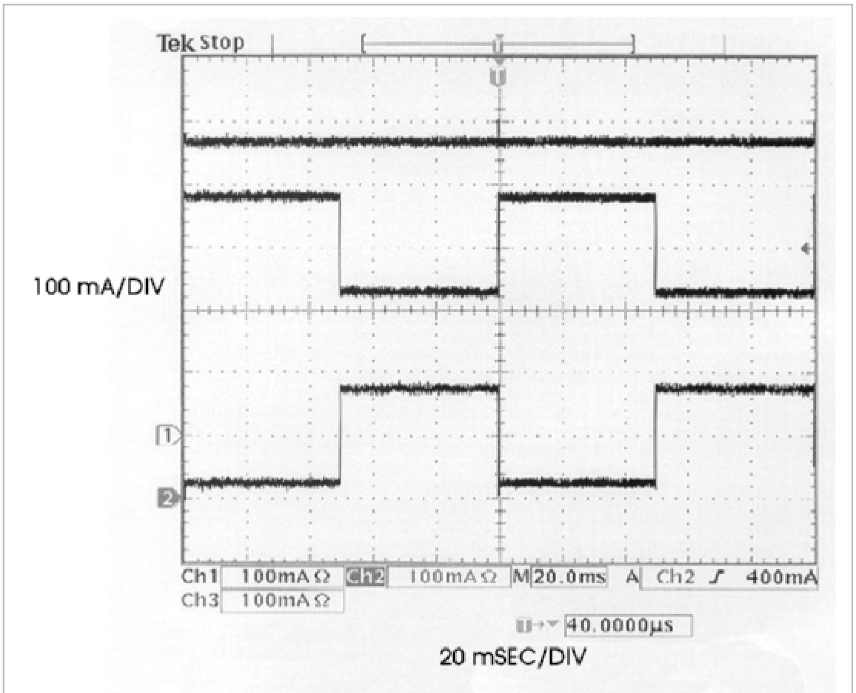

Figure 3 These waveforms taken from Figure 2 show that the sum of the essential-circuitry current (middle trace) and storage-element current (bottom trace) never exceeds the 500 mA maximum that the USB port (top trace) specifies.

device in the path of the energy-storage device (**Figure 1**). Although easy to implement, this method doesn't use all of the current available from the USB port, and the energy-storage device slowly charges or recharges.

The circuit in **Figure 2** uses all available USB power by dynamically adjusting the amount of current delivered to the energy-storage device and thereby siphoning a relatively constant and maximum current from the USB port. IC_1, a Maxim (www.maxim-ic) MAX4173FEUT; IC_2, a Maxim MAX6123AEUK25; and the load-switch circuit comprising Q_1, Q_2, R_2, and C_4 form a control loop that limits the current flowing through Q_1. The circuit maximizes current flowing to the energy-storage element (**Figure 3**) by ensuring that the sum of battery and essential-circuitry currents never exceeds the maximum of 500 mA for a high-power USB device. To reconfigure the circuit for low-power USB operation of 100 mA maximum, you can replace IC_1 with a MAX4173HEUT, a device with 100V/V gain, and R_1 with a 0.25Ω resistor. EDN

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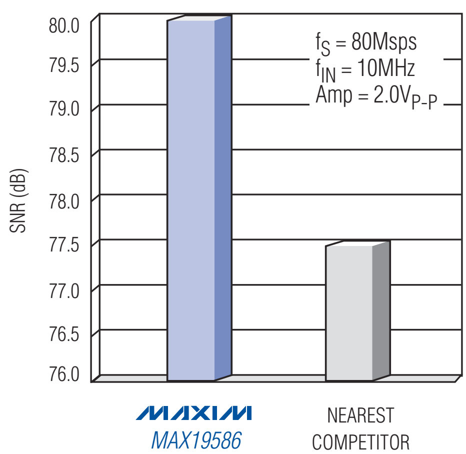

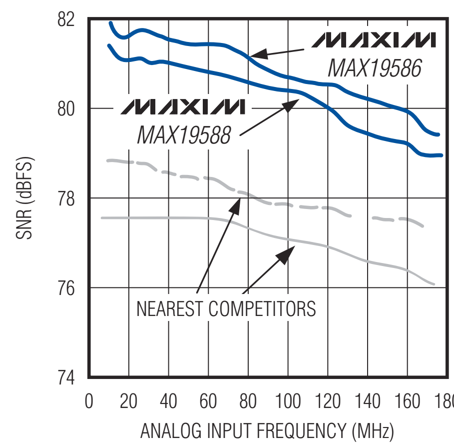

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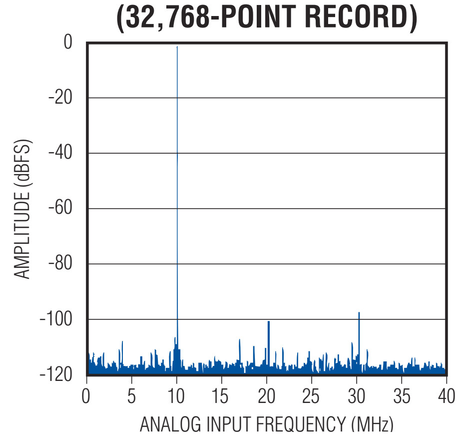

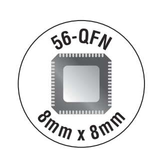

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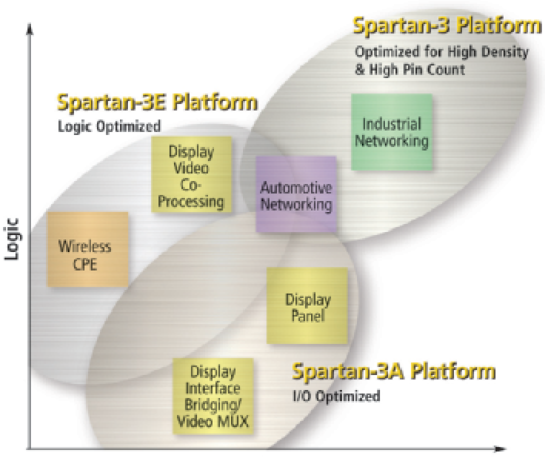

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Device provides large-bandwidth ESD protection for HDMI connections

Adding to the vendor's portfolio of ultralow-capacitance protection ICs targeting the high-definition-video market, the HDMIULC6-4SC6 allows an HDMI to operate at 1.65 and 3.2 Gbps with full 15-kV contact and air ESD protection. Providing 5 GHz of bandwidth, the monolithic, application-specific device features rail-to-rail protection of four data lines without compromising signal integrity. Available in an SOT23-6L package, the HDMIULC6-4SC6 costs 25 cents (2500).

STMicroelectronics, **www.st.com**

Micropackaged ESD diodes provide high levels of ESD protection

Targeting portable- and wireless-system applications, three ESD diodes are available in an SOD-923 package measuring 1×0.6×0.4 mm. The ESD9X3.3S, ESD9X5.0S, and ESD9X12S prevent damage to voltage-sensitive components on the board by clamping fast-rising ESD pulses. Providing the highest level of protection available in an SOD-923 package, as measured by the IEC61000-4-2 ESD-compliance standard, the devices facilitate placement near I/O ports where ESD can enter the system. The diodes suppress the transient voltage before it can couple into the rest of the board. Providing lower clamping voltage and lower leakage than multilayer varistors of comparable size, devices in the ESD9X series costs 3.4 cents (10,000).

On Semiconductor, **www.onsemi.com**

High-temperature SMD varistors run at low voltages

Suiting the automotive- and industrial-control market requiring low-voltage-transient protection above 125°C, the ZVY and AVY series SMD multilayer varistors provide a 150°C maximum operating temperature. The ZVY features operating ranges of 3 to 170V dc and 2 to 130V ac and response time of less than 2 nsec; the AVY features 12, 24, and 42V standard automotive voltages. Available in a variety of sizes, devices in the ZVY and AVY series cost 15 to 50 cents (10,000).

Stackpole Electronics, **www.seielect.com**

Resistors have extended surge ratings

Combining extended surge values with high voltage ratings, the PWC (pulse-withstanding-chip) series resistors suit power supplies and circuit-protection devices. Features include 125-mW, 330-mW, 750-mW, and 1.5W power ratings with 150, 200, 400, and 500V maximum-voltage ratings, respectively; a 1Ω to 10-MΩ resistance range, with ±0.5 to ±5% tolerances; and a −55 to +155°C operating-temperature range. Absolute TCRs (temperature coefficients of resistance) are 100 ppm/°C at 10Ω and 200 ppm/°C at less than 10Ω. Available in 0805, 1206, 2010, and 2512 chip sizes, devices in the PWC 2512 series costs 39 cents (5000).

IRC, **www.irctt.com**

Lightning protectors withstand 60-kA bidirectional transient surge

The ruggedized and weatherproof QSS 400 SurgeGuard quarter-wave-stub lightning protectors provide 60-kA bidirectional transient-surge protection. Targeting 802.11 Wi-Fi and WiMax applications, the devices feature 2.4 to 6 GHz of lightning protection and can withstand multiple strikes. Measuring 62.2×32 mm with N connectors, devices in the QSS 400 series costs $40.

NexTek, **www.nexteklightning.com**

MICROPROCESSORS

Enhanced Ethernet-stack IC features an SPI interface

Adding an SPI-interface and faster access to transmit/receive memory to the W3150Z Ethernet-stack IC, the fully hard-wired W3150A+ TCP/IP stack also features a dynamic, adjustable, internal, 16-kbyte transmitter/receiver buffer-size allocation. The device supports ADSL (asymmetric-digital-subscriber-line) connection with PPPOE (Point-to-Point Protocol Over Ethernet); port-unreachable information in UDP (User Datagram Protocol); four independent, concurrent sockets; and full-duplex mode. Throughput includes 8051 with a 1-Mbps maximum, AVR with an 8-Mbps maximum, ARM7 with a 21-Mbps maximum, and a 10/100 BaseT Ethernet with auto-detection. The device provides DHCP (Dynamic Host Configuration Protocol), telecommunications-network, FTP (File Transfer Protocol), HTTP (Hypertext Transfer Protocol), and DNS (Domain Name Server) X source code with the evaluation board. Available in a 64-pin LQFP ROHS (restriction-of-hazardous-substances) package with a 5V-I/O-tolerant 3.3V supply voltage, the device costs $5 (10,000).

Wiznet, www.wiznet.co.kr

Microcontrollers support an 80-MHz clock speed

Targeting automotive applications, the MB91F464AA and MB91F465KA 32-bit microcontrollers add on to the vendor's MB91460 series. Both devices include a CAN (controller-area-network) channel, 32 CAN message buffers, and five UART channels that comply with LIN (local-interconnect-network) standards. Suiting on-board entertainment and information systems, the 32-bit MB91F467RA microcontroller features two CAN channels, 32 or 64 CAN message buffers, and seven LIN-compliant UART channels. The three microcontrollers incorporate CAN interfaces and have 80-MHz clock speeds. The MB91F464AA comes in an LQFP-100 package and costs $8.52; the MB91F465KA comes in an LQFP-120 package and costs $9.73; and the MB-91F467RA comes in an LQFP-176 package and costs $17.04.

Fujitsu Microelectronics America, www.fujitsu.com

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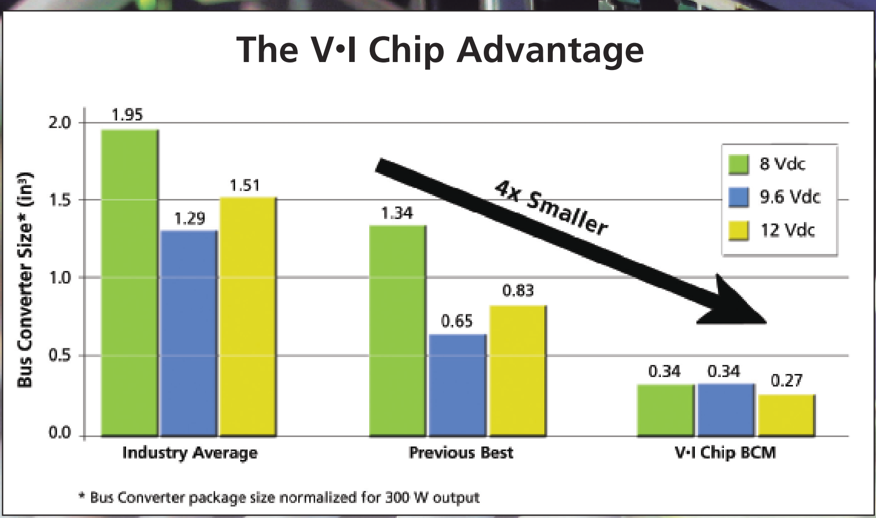

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B048F040T20	4.0	200 W	94.8
B048F060T24	6.0	240 W	95.6
B048F080T24	8.0	240 W	96.0
B048F096T24	9.6	240 W	96.2
B048F120T30	12.0	300 W	95.1
B048F160T24	16.0	240 W	96.0
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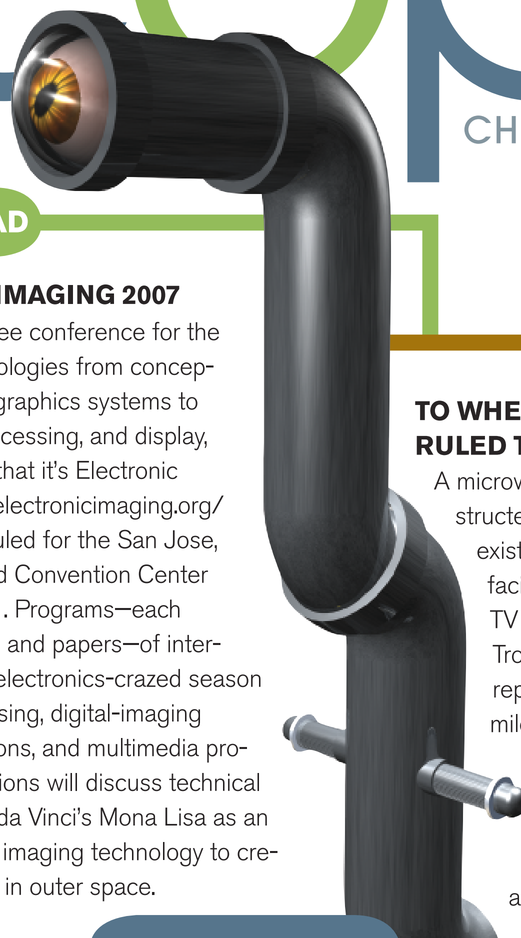

LOOKING AHEAD

TO ELECTRONIC IMAGING 2007

If there is one must-see conference for the whole range of technologies from conceptualization of human-graphics systems to image acquisition, processing, and display, a good bet would be that it's Electronic Imaging 2007 (www.electronicimaging.org/program/07/), scheduled for the San Jose, CA, Marriott Hotel and Convention Center Jan 28 through Feb 1. Programs—each including many tracks and papers—of interest in this consumer-electronics-crazed season include image processing, digital-imaging sensors and applications, and multimedia processing. Plenary sessions will discuss technical aspects of Leonardo da Vinci's Mona Lisa as an image and the use of imaging technology to create a virtual presence in outer space.

LOOKING BACK

TO WHEN WIRELESS DINOSAURS RULED THE EARTH

A microwave radio system to be constructed in the near future will extend existing long-distance telephone facilities and accommodate network-TV broadcasts throughout Canada. Tropospheric propagation between repeater stations located 30 to 40 miles apart will be employed. … Operation will be [at] around 4,000 Megacycles and will provide six channels in each direction. Each channel will accommodate 600 telephone circuits or one black-and-white video signal. Under some conditions, both a video channel and a limited number of telephone circuits may be sent. … Because of the low (one-half-watt) power level to be used, each tower will support antennas with highly directional characteristics.

—*Electrical Design News*, December 1956

LOOKING AROUND

AT A CHANGING US CONGRESS

The waning of December will mark the end, at least for now, of the Republican-dominated Congress. The press has made much of the incoming Democratic majority and its views on President George W Bush and the war in Iraq. But we've heard little or nothing from the Democrats, either as a party or as individuals, on issues nearly as vital to engineers. For example, where will the new Congress stand on immigration and H1B visas? What are the Democrats' views on intellectual-property law (badly in need of updating), export controls, and outsourcing? How will the new Congress act on support for education, basic research, and technology development, in all of which areas the United States is rapidly slipping? Such issues don't make good campaign sound bites, but they can make or break an industry.